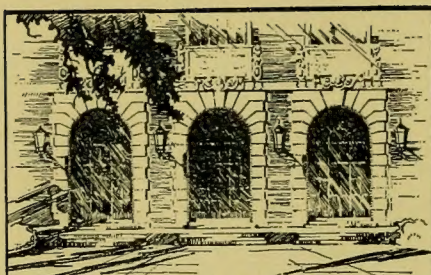




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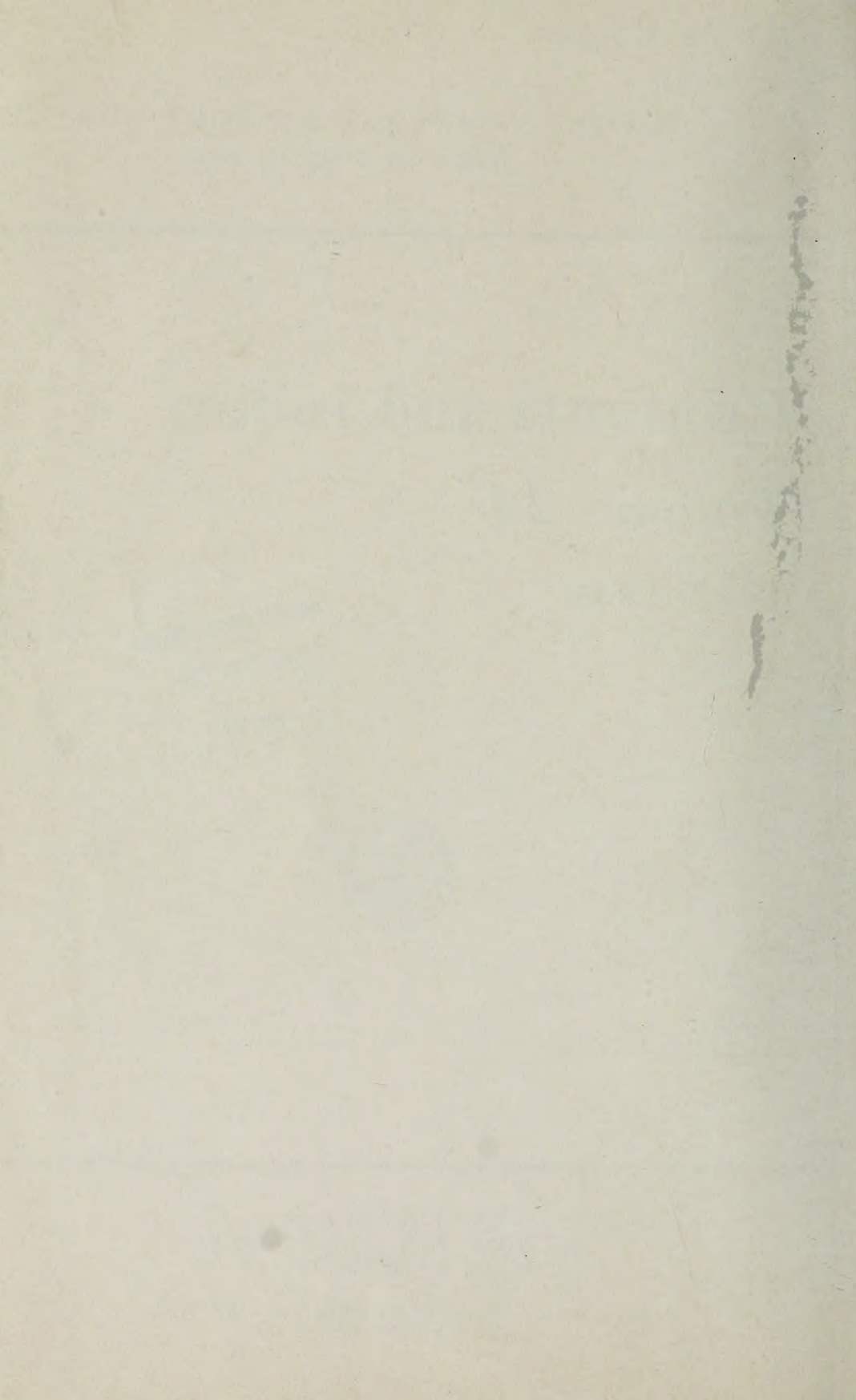
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This paper is a contribution from the Section of Publications and Public Relations.

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- Page 182, couplet 5, line 9. *For 35 substitute 36.*
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- Page 188, 41. *SCAPHOIDEUS* Uhler. Correspondence between Dr. D. M. DeLong and Dr. P. W. Oman has revealed that the type series of *Scaphoideus luteolus* Van Duzee is composed of at least two species and as a result there has been some confusion in the use of this name. *Scaphoideus luteolus* Van Duzee, as represented by the type female in the United States National Museum, is the same species as *Scaphoideus baculus* DeLong & Mohr. The species in this report identified as *Scaphoideus luteolus*, based on the paratype male in the Osborn collection at Ohio State University, is a different species from that of the type female of *luteolus*. The name *motus* DeLong has been proposed for the misidentified form *luteolus* DeLong *nec* Van Duzee. This necessitates the first eight of the following changes.
- Page 188, couplet 5. *For luteolus substitute motus.*
- Page 189, fig. 248. *For LUTEOLUS substitute MOTUS.*
- Page 190, couplet 22. *For baculus substitute luteolus.*
- Page 191, couplet 34. *For baculus substitute luteolus.*
- Page 191, couplet 37. *For luteolus substitute motus.*
- Page 192, fig. 274. *For BACULUS substitute LUTEOLUS.*
- Page 197, 12. *For Scaphoideus baculus* DeLong & Mohr, *substitute Scaphoideus luteolus* Van Duzee.
- Page 202, 31. *For Scaphoideus luteolus* Van Duzee *substitute Scaphoideus motus* DeLong.
- Page 478, column 1, line 24 from top. *For Toumey substitute Twomey.*
- Page 481, column 1, line 21 from top. *For Toumey substitute Twomey.*

BULLETIN

of the

ILLINOIS NATURAL HISTORY SURVEY

HARLOW B. MILLS, *Chief*

The Mosquitoes of Illinois

(Diptera, Culicidae)

HERBERT H. ROSS



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Volume 24

BULLETIN

Article 1

The Mosquitoes of Illinois

(Diptera, Culicidae)

HERBERT H. ROSS



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URBANA, ILLINOIS

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One of the largest Illinois mosquitoes is the "gallinipper," *Psorophora ciliata*, which may attain a wingspread of 15 mm. (over half an inch). It is a vicious biter and is generally distributed over Illinois. The larvae or wigglers of this species breed in rain pools and have the habit of feeding on larvae of other mosquito species.

The Mosquitoes of Illinois

(Diptera, Culicidae)

HERBERT H. ROSS

MOSQUITOES are midgelike insects of various sizes, some of them minute, some of them nearly a half inch long. They belong to the family Culicidae, which belongs to the order Diptera, embracing the common housefly and other two-winged flies. Mosquitoes have aquatic larvae called wiggle-tails, wigglers, or wrigglers, which transform to aquatic pupae called tumblers. The adults, which emerge from the pupae, are aerial.

About 150 species of mosquitoes are known to occur in the United States and Canada, and 52 of these have been taken in Illinois. The Illinois mosquito fauna represents a combination of the northern and the southern mosquito faunas, a combination not yet treated in the various reports giving keys to the faunas of limited regions.

Mosquitoes are a real nuisance in many parts of Illinois. Although some of the more intensively farmed areas are comparatively free from all but local incursions of mosquito broods brought on by unusual weather conditions, in all other parts of the state mosquitoes are a perennial problem. An extremely vicious biter, the salt marsh mosquito, *Aedes sollicitans*, has invaded a few Illinois cities. The malaria mosquito, *Anopheles quadrimaculatus*, is a menace to human health in some areas. To be economical as well as effective and thorough, a control program for these and other mosquitoes must be based on accurate identifications of the species involved and a knowledge of their peculiarities of life history and habits.

The nation's annual "mosquito bill" is high—probably \$100,000,000 due to mosquito-borne diseases, and close to \$50,000,000 for screening, pest control programs, and depressed real estate values.

The object of this paper is to provide means for making mosquito control programs more effective, first by furnishing illustrated keys and descriptions for the identification of mosquito species that occur in Illinois and states similar in climate, and

second by summarizing information regarding the distribution, biology, and habitat preferences of the species.

BIOLOGY

Mosquitoes, in common with other groups of flies, have four distinct stages in their life history: (1) the egg, laid by the female; (2) the larva, wiggle-tail, wiggler, or wriggler; (3) the pupa, or tumbler; and (4) the adult fly.

Eggs

Eggs deposited by Illinois species of mosquitoes fall into three fairly distinct categories: (1) those laid singly on water; (2) those glued together in rafts that float on water; and (3) those laid singly in damp humus or other semidry material.

Eggs Laid Singly on Water.—In this category belong the eggs of *Anopheles*, fig. 1C. They are elongate oval, usually pointed at one end, and have a pair of lateral floats. From 100 to 300 eggs may be laid by an adult female after taking a blood meal; usually the eggs hatch in a few days. Little is known about the eggs of the tree hole genus *Megarhinus* except that they are laid singly on the surface of water. *Anopheles* and *Megarhinus* are the only genera in this class known to occur in Illinois.

Eggs Laid in Rafts on Water.—The eggs of many mosquito genera are deposited side by side in such a manner as to form a raft, fig. 1A. This raft floats on the surface of water, and the eggs hatch in a few days, each larva escaping from its egg at the end that touches the water. The raft may contain a hundred eggs or more. In the genera *Culex*, *Culiseta*, *Mansonia*, and *Uranotaenia*, eggs are deposited in rafts. The larvae of all these groups breed in permanent bodies of water.

Eggs Laid Singly in Semidry Places.—In many genera of mosquitoes, including *Aedes*, *Psorophora*, *Orthopodomyia*, and

Wyeomyia, the eggs are laid out of water, but they do not hatch until water has risen and inundated them. The eggs may be laid either just above the water line in such situations as tree holes, various water containers, and marsh edges, or in damp humus in the bottoms of recently dried-up pools that are subject to periodic flooding. The eggs of *Aedes*, fig. 1B, and *Psorophora*, normally

known as *intermittent breeders*. They include all species of *Psorophora* and certain species of *Aedes*: *vexans*, *sollicitans*, *trivittatus*, and many southern species. In the other class, called *annual breeders*, because only one generation is developed each year, the eggs must be subjected to winter freezing before they develop. Eggs laid by the adults of one generation do not hatch with

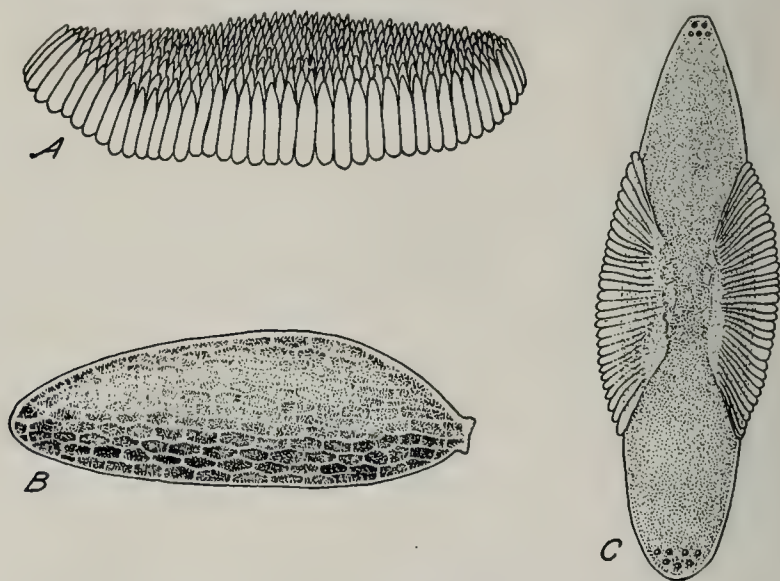


Fig. 1.—Eggs of mosquitoes: A, *Culex restuans*; B, *Aedes taeniorhynchus*; C, *Anopheles quadrimaculatus*. (After Howard, Dyar, & Knab.)

laid in damp humus, are adapted to withstand desiccation and may lie dormant 1 or 2 years without losing their viability. *Wyeomyia* lays its eggs above the water line in the pitcher plant, and these eggs do not hatch until the water within the pitcher rises. The same habit is a characteristic of the tree-hole mosquitoes, *Orthopodomyia* and *Aedes triseriatus* and *aegypti*, which lay eggs on the sides of tree holes or water containers just above the edge of the water so that with a rise in the water level the eggs hatch.

The species of *Psorophora* and *Aedes*, which lay their eggs out of the water, may be divided into classes with respect to significant differences in egg hatching. In one class the eggs hatch as soon as they are flooded; since in this species the life history is completed rapidly, several generations usually are produced in a summer as pools dry and flood with alternate dry and rainy periods. Species belonging to this class are

summer flooding but lie dormant through the winter and hatch the next spring. To this class belong many species of *Aedes* such as *grossbecki*, *stimulans*, and *implacabilis*.

Larvae

The mosquito larva or wriggler, fig. 2, has a distinct head, broad thorax, and tubular abdomen. It lives only in water. The larval period is one of feeding, during which the small larva hatching from the egg grows to a size large enough to produce the adult fly. Unlike the adult, this larva has no beak and does not suck food; instead it has a series of brushlike rakes in addition to the grinding and grasping mouthparts, a combination enabling it to strain, scoop, and ingest small aquatic organisms and particles of plant or animal matter floating in or upon the water or resting on the bottom. In the

few genera in which the larvae are predaceous on other mosquito larvae, the mouthparts are sharp-toothed for grasping and swallowing the prey.

Unlike fish, the wriggler does not obtain oxygen from the water by means of gills. When in need of air, the larva in most species swims upward until it is just below the surface of the water, if it is not already there, and sticks the breathing apparatus (in some species a tube and in others a plate), which is near the end of the abdomen, through the surface tension membrane into actual contact with the air, fig. 2. With the larva in this position, the air inside the body is exchanged for fresh air above the water. Among Illinois mosquitoes, only the larva of *Mansonia* does not come to the surface for air. In this species, fig. 18, the air tube forms a sharp, piercing organ, which is thrust into the air chambers in the underwater portions of marsh plants such as the cattail. The larva of *Mansonia* obtains its oxygen entirely from this source.

The larvae of Illinois mosquitoes may be divided into two distinct types on the basis of breathing structures and feeding habits, the anopheline type and the culicine type. In the anopheline type (including only the genus *Anopheles*), the larvae normally rest parallel to the surface, touching the surface tension membrane, fig. 2A. They have no air tubes; the spiracles form a flat structure on the back of segment 8. The larvae normally twist their heads through a 180-degree angle and feed on microorganisms or other particles at or on the surface, but occasionally feed below the surface much as do culicine larvae. When disturbed they swim to the bottom and hide. In the culicine type, the larvae normally feed on or near the bottom and come to the surface only periodically for air. This group includes all of the Illinois mosquitoes except *Anopheles*, and all of them have distinct air tubes. The predaceous species, such as *Psorophora ciliata*, do not feed on bottom microorganisms but usually cruise near the bottom and grasp their prey

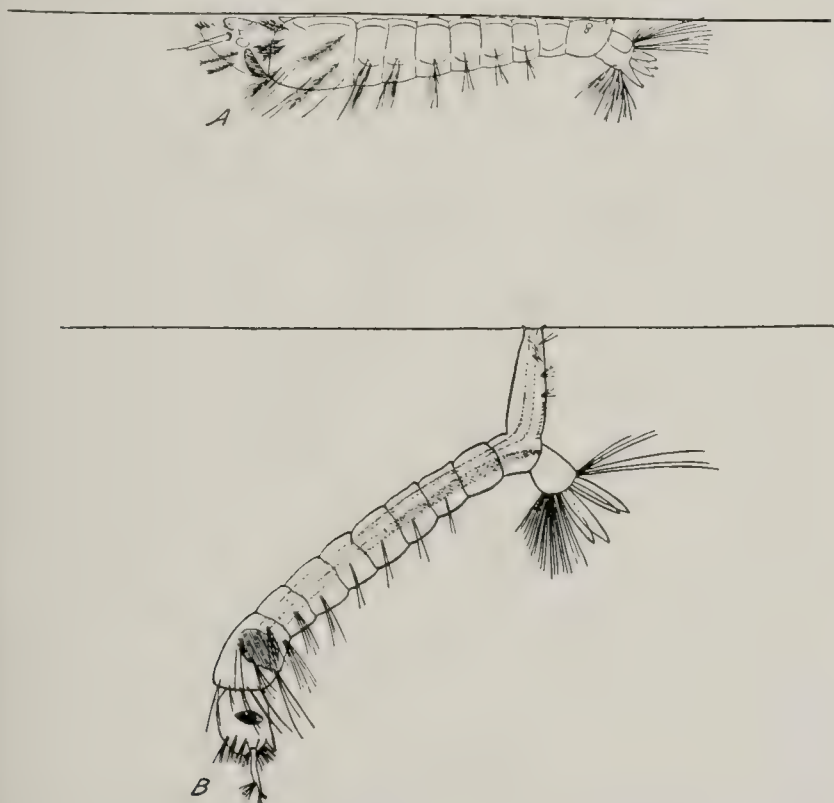


Fig. 2.—Larvae of mosquitoes: A, *Anopheles*; B, *Culex*. (After King, Bradley, & McNeel.)



Fig. 3.—Pupa of mosquito. (After King, Bradley, & McNeel.)

there. The curious genus *Mansonia* is also included in this group although, as mentioned above, it does not come to the surface for air. It is a true bottom feeder.

Pupae

The pupae do not feed but they breathe in the same manner as the larvae; the air tube is situated on the thorax, fig. 3, instead of near the end of the abdomen as in the larvae. The pupal stage, in which the muscular and other body structures of the larva

are broken down and reorganized into the structures of the adult, generally lasts only a few days. At the end of that time the mature pupa comes to the surface of the water, and the adult within it breaks the pupal skin, crawls out onto the surface of the water, and flies away.

Adults

Mosquito adults, fig. 4, are fairly small, delicate, winged flies, quite slender, and always with long, spindly legs. All the adults of the true mosquitoes have beaks. The visible part of the beak is a scabbard or sheath in which a group of extremely fine stylets makes up a needle-like piercing and sucking organ; it is the function of the sheath to keep this slender needle straight when it is thrust through the skin of the animal upon which the female mosquito feeds. Both males and females fly with a distinct humming or buzzing sound.

Only the female mosquito "bites," or feeds upon animals; the male feeds on nectar and water. Whereas the female seeks out her prey and may travel long distances to it, the male is relatively inactive, generally hiding in grass or shrubbery except during the mating flights. There is evidence that the female does not bite for several



Fig. 4.—Adult of *Aedes aegypti*. (From photograph, loaned by the U. S. Public Health Service, of model in the American Museum of Natural History.)

days after she becomes an adult. Not all species bite humans. Some feed on nectar, and it is thought that a few others feed chiefly either on plant juices or the blood of birds and small mammals.

Females of most species seek their blood meal during the dusk and night periods. Many of these same mosquitoes attack readily in the late afternoon or on cloudy days and during the dawn period. The woodland species almost invariably bite throughout the day, although their attacks are usually most vicious during the crepuscular period. A few species attack readily in the open during the day time. Probably the best known Illinois species having this habit is *Anopheles walkeri*. Of unusual interest is the biting habit of *Psorophora cyaneescens*, which attacks in the open and during times of bright sunlight.

Flight habits of mosquitoes have been the subject of considerable study, in which marked or colored specimens have been released and their recovery in light traps or resting places has been plotted. A species of mosquito apparently will behave differently under different conditions. It is usually considered that malaria mosquitoes normally have a flight range of not more than 1 or 2 miles. Probably the longest flight ranges occur in species of *Aedes*. It is not unusual for summer swarms of *Aedes vexans* to migrate 2 or 3 miles and possibly up to 15 miles, and the salt water mosquito, *Aedes sollicitans*, has been known to migrate 40 or 50 miles. Many woodland species appear to be fairly restricted in their movements and seldom leave the piece of woods in which they have matured.

The length of life of adult mosquitoes is not well known. Some of the *Anopheles* and *Aedes* females undoubtedly live 1 or 2 months during the summer period. The adults that hibernate have a much longer life span.

Hibernation

The great majority of Illinois mosquitoes, including most of the species of *Aedes* and *Psorophora*, hibernate in the egg stage. A few species, such as *Wyeomyia smithii*, *Anopheles barberi*, and species of *Orthopodomyia*, hibernate as larvae frozen in pitcher plants or tree holes in which they breed. *Anopheles*, *Culex*, and at least *inornata* of *Culiseta* overwinter as fertilized females.

The males die with the advent of cold weather. The females hide in hollow trees, cellars, manholes, and other sheltered places, from which they emerge in spring and lay eggs.

Habitat Preferences

The various species of mosquitoes differ greatly in the type of habitat frequented by the larvae. Some species breed in a great variety of situations, whereas others are extremely restricted in their breeding places. The following summary outlines in a general way the habitats preferred by the Illinois species.

Running Water.—*Anopheles punctipennis* usually breeds in small streams, frequenting the edges and shallow areas where the current is sluggish. This species breeds with equal success in still water. A few species of *Culex* sometimes breed in moving water heavily laden with organic matter where the current is slow. These same species normally breed in still water.

Still Water.—All Illinois species will breed in still water, and most of them only in still water, chiefly small ponds and pools of many types, the shallow edges of lakes, and the still water in shallow, dense weed beds along the edges of streams. Still water habitats are of several types and may be classified as permanent, temporary, specialized, and semidomestic areas.

PERMANENT AREAS.—All species that lay eggs on the surface of the water, whether singly or in rafts, frequent permanent water areas. All prefer areas with shallow water and little wave action, abundant cover in the form of at least moderate aquatic vegetation, and abundant food in the form of humus or other organic matter on the bottom and floating particles or microorganisms at the surface. Marshes, fig. 5, or shallow ponds with cattails, sedges, and associated aquatic vegetation are ideal for many mosquito species.

TEMPORARY AREAS.—In this category are ponds that fill with water intermittently for variable periods. In all these ponds one of the chief requirements for a good mosquito habitat is that they have ample organic matter (usually in the form of rotting leaves) on the bottom.

In Illinois, temporary ponds are extremely varied with respect to how and when they are filled, where they are situated, and how



Fig. 5.—Marsh near Hinsdale, Illinois. In spring the more abundant mosquitoes at the marsh edge include *Culiseta inornata*, *Aedes fitchii*, *Aedes vexans*, and *Culex apicalis*.

long they last. Most of them fall into one of four classifications: winter seepage ponds, flood plain ponds, summer rain ponds, and marsh edges.

Winter seepage ponds fill up during the winter or early spring with surface or seepage water from winter precipitation or the spring thaw. Ponds of this type, fig. 6, may have water in them for several months, but during much of this time the weather is too cold to allow mosquito development. They support many of our most vicious early spring *Aedes*, especially *canadensis*, *stimu-*

lans, *grossbecki*, and *implacabilis*. The same species occur in flooded stump holes, fig. 7.

Flood plain ponds form with the overflow and retreat of streams that leave isolated pools of water scattered throughout the flood plain. These are favorite places for many *Aedes*, especially the early spring species *sticticus*, and some *Psorophora* species.

Summer rain ponds form in many depressions during heavy summer rains and remain for periods of a few days or weeks. In these breed *Aedes vexans* and many species of *Psorophora*



Fig. 6.—Woodland pool, Bensenville, Illinois. This spring pool contains an enormous population of *Aedes stimulans*. It dries up in summer.



Fig. 7.—Stump hole, Bensenville. A favorite habitat of *Aedes canadensis*.

Marsh edges that are alternately flooded and exposed by the rise and fall of water give the same conditions as temporary ponds, as far as mosquitoes are concerned. These marsh edges or margins, fig. 5, are important mosquito breeding grounds, especially for *Aedes vexans*.

SPECIALIZED HABITATS.—Two situations of unique interest from the standpoint of the mosquito fauna are tree holes and pitcher plants. Each of these may harbor species of mosquitoes found in no other situation. Tree holes, fig. 8, include cavities within standing tree trunks and inside fallen trees (Jenkins & Carpenter 1946).

Illinois mosquitoes that are restricted to this habitat include *Megarhinus septentrionalis*, species of *Orthopodomyia*, *Anopheles barberi*, and *Aedes triseriatus*. The tree holes fill up either with rain water or with sap that has risen within the wounded tissues. Larvae that live in the tree holes develop much more slowly than is usual for species living in ponds. Only one Illinois species of mosquito, *Wyeomyia smithii*, breeds in pitcher plants; it is found in no other situation. Its larva feeds on decomposing animal material trapped in the pitcher.

SEMIDOMESTIC SITUATIONS.—Several species of mosquitoes breed readily in situations around human habitations. They breed in the water that accumulates in fish ponds, tin cans, or almost any other type of container, fig. 9. They may frequent also the accumulation in stopped-up eaves troughs, drains,

and cisterns. In Illinois the chief species found in these situations are *Culex restuans*, *pipiens*, and *quinquefasciatus*. In contain-

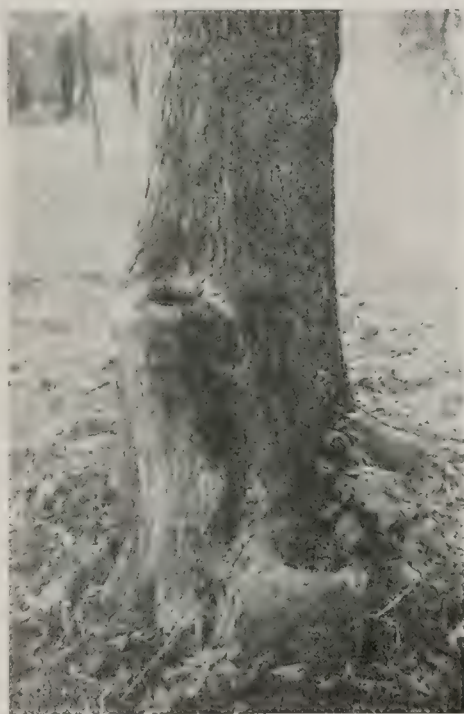


Fig. 8.—Tree hole at Starved Rock State Park. This is the habitat for *Aedes triseriatus*, *Orthopodomyia* species, and *Anopheles barberi*.



Fig. 9.—Refuse heap near Wilmette, Illinois. Water in the containers is a favorite breeding place for *Culex pipiens* and *restuans*.

ers that are out of doors and that have in them an abundance of organic material (neglected fish ponds are the favorites), *Anopheles punctipennis* may breed in enormous numbers. *Aedes aegypti* also breeds in similar containers, usually those inside buildings.

SEASONAL DISTRIBUTION

The various mosquito species appear in a fairly definite sequence as the season advances. The earliest species are *Aedes*, whose larvae develop in the spring pools. In southern Illinois the principal species are *canadensis*, *grossbecki*, and *sticticus*, through the central part of the state *canadensis* and *sticticus*, and in the northeastern part *stimulans*, *implacabilis*, *fitchii*, and others. In southern Illinois the first emergence may occur as early as April 1, in northern Illinois by the middle of May, but usually first emergence is about two weeks later than these dates. The early *Aedes* listed above are without exception annual breeders. They are followed in rapid succession by *Culiseta inornata* and *Culex apicalis*. A week or so after these appear, the large number of summer species begin to make their appearance. These include *Anopheles*, several species of *Culex*, and usually *Aedes vexans* and *trivittatus*. The summer species continue to breed in suitable locations throughout the summer or intermittently with the summer rains.

A third group of species, which includes *Culex quinquefasciatus* and *Uranotaenia sapphirina*, may be present early in the season, but an appreciable population of this group usually does not appear until at least midsummer.

When the spring weather is uniformly cold well into May, and then is followed by a series of warm weeks, early and midseason species come out together, and there is little demarcation apparent between seasonal groups.

DISTRIBUTION PATTERN

The mosquito fauna of Illinois resolves itself into three well-marked groups: (1) species of wide distribution, which are generally distributed in Illinois; (2) northern species that have a range widespread to the north, and that occur in only the northern portion of the state; and (3) southern species that have a range extending only slightly into Illinois and that are only sporadic north of the southern third of the state.

The species that are generally distributed include some of our most abundant nuisance species, such as *Aedes vexans*, *trivittatus*, *canadensis*, and *sticticus*, *Psorophora ciliata* and *ferox*, *Culex pipiens*, *apicalis*, and *restuans*, and *Culiseta inornata*.

Northern species whose range extends into northern Illinois include many of the annual-breeding large *Aedes* found in the glacial bogs and marshes in the extreme northeastern corner of the state. These species are *Aedes implacabilis*, *punctor*, *stimulans*, *excrucians*, *fitchii*, *flavescens*, and *cinereus*. A few of these, such as *flavescens* and *punctor*, are rarities; *excrucians* is present in only moderate numbers; the other species breed tremendous populations. Other mosquitoes in this northern group include *Culiseta morsitans*, confined to the tamarack bogs, and *Wyeomyia smithii*, the pitcher plant mosquito, which also occurs only in tamarack bogs. On the basis of Illinois collecting, *Anopheles walkeri* appears to be in the same group, since in this state it is abundant only in the cattail marshes and bogs of the northern part; records from other states indicate, however, that its range extends far to the south where marshes are available. Another northern mosquito taken in Illinois is *Aedes spencerii*, for which our only record came from the northwestern corner of the state.

Many southern species have been taken in the extreme southern tip of Illinois, most of them in the woodland pools of the post oak flats in the Mississippi River valley. The post oak flats list includes *Aedes fulvus*

pallens, *dupreii*, and *grossbecki*, *Psorophora howardii*, and *Anopheles crucians*. *Aedes thibaulti* has been taken near Carbondale, only 50 miles north of Cairo at the southern tip of Illinois. *Psorophora discolor*, *varipes*, and *cyaneescens*, and *Megarhinus septentrionalis* are southern species which often occur in the southern eighth or fourth of Illinois and sometimes sparingly north of that.

Aedes aegypti is another southern mosquito that has been taken in the St. Louis area and southward. Apparently it is unable to maintain itself there and occurs only as a temporary adventive during favorable years.

The southern house mosquito, *Culex quinquefasciatus*, which has been taken in some numbers in southern Illinois, occasionally extends northward at least as far as Urbana. Present collection data are far from conclusive but suggest that unfavorable winters push back the range of this species and that it migrates northward again during a succession of favorable years.

Perhaps our most unusual record is that for *Aedes aurifer*, a northern and eastern mosquito for which we have only one Illinois record, from the extreme southern tip of the state. Almost as unusual is the occurrence of the northern *Aedes cinereus* in the same locality. Presence of these northern species in southern Illinois illustrates a tendency, which has been noticed in several other insect groups, for occasional northern species to occur in or near the Mississippi River region south of the main body of their range.

ECONOMIC IMPORTANCE

Mosquitoes cause an economic loss both as nuisances and as disease carriers.

The nuisance category includes all those species that inflict painful bites but that are not known to carry diseases. Most important in this group are the various species of *Aedes* and *Psorophora*; in cities and towns, species of *Culex* are of prime importance. Mosquitoes in the nuisance group inflict financial loss in various ways. In some sections they restrict the vacation season, with subsequent loss of patronage to resort establishments. They attack domestic animals and fowls and, when in large numbers, cause loss of weight and health. It has been estimated that 500 mosquitoes will draw one-twentieth of a pint of blood per day from an exposed animal. Sometimes mosquitoes

become so abundant as to interfere with or stop work by man, with a consequent loss of labor and accomplishment. Mosquitoes are among the worst nuisances of the out-of-doors and prevent enjoyment of recreational facilities by many people seeking exercise and relaxation.

Disease-transmitting mosquitoes are the sole vectors of malaria in human beings. Malaria is an endemic disease in southern Illinois. Only 50 miles to the south of Illinois, in the Mississippi River valley, occurs one of the high density areas of this disease in eastern North America. *Anopheles quadrimaculatus* is considered the only important mosquito species capable of transmitting the disease in Illinois.

Several other human diseases, such as yellow fever, filariasis, and dengue, are transmitted by certain species of mosquitoes that occur in Illinois. However, recent outbreaks of these diseases are so far removed geographically from Illinois, or the known mosquito vectors are so rare in this state, that the diseases are not considered a serious threat to Illinois citizens at the present time.

Public health workers have pointed out that a number of the service men returning from areas in the Pacific and Oriental regions where many insect-borne diseases occur will have been infected with these diseases. It is entirely possible that, upon returning home, the men may be a source from which mosquitoes may become infected with some of the tropical diseases and transmit them to other persons resident in the same locality. There is little possibility of knowing when and where such situations will arise. At the present time this problem seems to resolve itself into one of early detection and accurate diagnosis of the diseases by local medical authorities.

Up to the present time measures instituted against mosquitoes in Illinois have been directed toward abatement of nuisance species or toward control of the malaria vector, *Anopheles quadrimaculatus*.

CONTROL CONSIDERATIONS

Control measures require consideration as individual problems in each community or locality. In different localities different species of mosquitoes are encountered, bringing into the control problem the treatment of different habitats, and involving differences in number and seasonal timing of

mosquito generations. Vagaries of precipitation or flooding frequently require rapid and unexpected changes in control plans.

Control measures, to be both economical and thorough, must be based on data obtained by a collecting and identification program. It is wasteful to attempt control measures of every water surface within an area, because many bodies of water (and frequently the most extensive ones) do not serve as breeding places for mosquitoes. Before actual control measures are planned, therefore, larval collections should be made that will serve as a guide to the areas to be treated.

To check the efficiency of control operations, it is necessary to supplement larval collections with biting records and adult collections throughout the season. These should include light trap collections and collections from resting stations.

The persistence of adult mosquitoes in a control area (shown by collections and biting records) may indicate that breeding places within the area have been overlooked or that mosquitoes are coming in from surrounding territory. After overlooked sites have been eliminated, collection and identification of larvae from breeding places in surrounding territory will indicate additional places which should also be treated.

When adult mosquitoes are identified as to species, facts about them, fundamental in controlling them, can readily be ascertained: (a) the types of situations in which larvae should be sought and (b) breeding habits, that is, whether the mosquitoes are annual, intermittent, or persistent breeders. Such information is useful in searching out places where control treatments must be applied and determining whether the treatments need to be applied only once a year for annual breeders, following rains or floods for intermittent breeders, or at regular intervals for persistent breeders.

COLLECTING AND PRESERVING

Mosquitoes, both adults and larvae, are so delicate that their hairs and scales, upon which identification is based, are readily broken or rubbed off by careless handling. For this reason it is necessary to use great care in the procurement of material and in its subsequent handling and preparation for study.

Larvae

A white enameled dipper, about 6 inches in diameter, is the most convenient utensil for collecting mosquito larvae. It may be used to dip up larvae from ponds and open water. The larvae can be removed from the dipper by one of two methods: (1) by pulling them into a wide-mouth medicine dropper and then discharging them into a vial of preservative or into a rearing capsule or (2) by pouring the contents of the dipper slowly onto a cloth strainer, picking the larvae off the cloth with forceps, and transferring them to a preservative or to a rearing vial. Hairs of the larvae are easily knocked off or the larvae mutilated in other ways if the transfer is made carelessly.

Alcohol makes a satisfactory preservative; 80 per cent alcohol is strong enough if the larvae are transferred to it with forceps. If a medicine dropper is used to transfer the larvae, a few drops of water will be discharged into the preservative with each larva, and a stronger solution of alcohol should be used. Not more than two live larvae should be placed at the same time in a single vial. If many thrash around in the vial, they knock the hairs off each other. As many as 10 larvae may be put in a three-dram vial, but they should be put in one at a time; the second and succeeding larvae should not be put in until the first and others have died. The most satisfactory way to kill a larva desired for a specimen is to place it in a separate killing vial and transfer it to a stock vial after it has died.

If larvae are handled in a vial only partially filled with preservative, they will jounce around, with a consequent loss of hairs and tufts. If the specimens are in a vial that is filled with preservative, without a single air bubble in it, they will move only slowly, no matter how violently the vial is agitated, and suffer no damage.

To preserve larvae in this way, the following procedure is recommended. Put the dead larvae in a small shell vial; put this vial, open end up, in a larger vial containing alcohol above the top of the shell vial. Now pick up a plug of cotton with a pair of forceps, soak the cotton with alcohol, and plug the open end of the shell vial with the cotton under the alcohol. Then take the shell vial out of the larger vial, put it in again plugged end down, and stopper the large vial, fig. 10A.

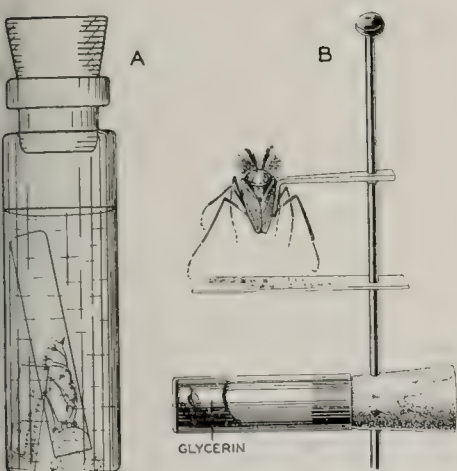


Fig. 10.—A, vial with inner vial containing mosquito larvae. B, mosquito mounted on crimped point and genitalia in microvial with pin through cork.

The plug is prepared by rolling a small piece of cotton between the fingers until it is fairly hard; after a little practice, a plug can be gauged that will fit the shell vial tightly but that is not so large that the vial will be broken when the plug is forced in. For storage, the larger vial should be kept well filled with alcohol; no evaporation will occur from the inner vial until the alcohol in the outer one is almost gone.

Adults

There are three principal methods of collecting adult specimens: (1) by placing a killing tube over them as they sit in natural resting places or as they alight to bite, (2) by sweeping them from vegetation around their breeding places or sweeping them in the air as they swarm in mating flights, and (3) by attracting them to light traps.

Killing Tube.—Collecting adults with a killing tube calls for the same careful individual attention as does collecting larvae. Scales of the adults rub off very easily. For this reason, a tube with a strong killing agent should be used and only one live mosquito should be placed in a tube at one time, never more than 6 to 10 dead ones. It is wise to carry several boxes with loose, crumpled cellucotton in the bottom and to transfer to these each dead mosquito from a killing tube. These boxes, which should have tight-fitting lids to prevent accumulation of dust on the specimens, should be so placed some-

where in the vehicle used for transport that they will not tip.

Sweeping.—Sweeping around vegetation does not net good study specimens of females, but it is valuable in collecting males. Frequently the males are present around a pond after all the immature stages in it have matured. Collections of males often give an accurate clue as to the species that develop in the pond, and their proportionate populations. The type of sampling done by sweeping vegetation is especially valuable in scouting temporary pools. A standard sweep net can be used, and the males picked out of the net with an aspirator. If the collector desires to obtain, by using a net, female mosquitoes that are in good condition, it is advisable that the net bag be made of very fine, light material. For routine collections of males, it is more practical to use a heavy bag that will withstand the abuse involved in hitting shrubs, thick herbage, and the like.

Light Traps.—A standard light trap used



Fig. 11.—Light trap. (Photograph by courtesy of Bureau of Entomology and Plant Quarantine, U.S.D.A.)

for mosquitoes at the present time is the New Jersey light trap, fig. 11. This attracts mosquitoes by means of a low wattage electric light bulb and is provided with a fan that blows them into a killing jar. The light bulb and fan are fastened to the inside of a large cover, which sheds rain, and a funnel is below the fan, fastened to three legs that support the trap when it is placed on the ground. The standard trap has a handle on the top, so that in the field it may be hung in a tree or from some other support. Mosquito specimens collected in this type of trap are usually in fairly good condition. Occasionally a swarm of beetles will be attracted to the light and blown into the killing jar. The beetles will crawl and thrash through the collection and mangle the mosquitoes.

Individual catches from each trap should be placed, while still pliable, between layers of cellulocotton in pill boxes. These layers should be thick enough to dry the insects thoroughly; otherwise mold may engulf the collection and render it useless for study. At the top of the pill box enough extra cotton should be added so that, when the lid is put on, the contents will be held firmly, but not so tightly as to crush the specimens. The container may then be transported without injury to the contents. A collection of pill boxes having different diameters and cardboard boxes 2 by 3 inches to 3 by 5 inches gives a good selection for handling catches of various sizes. These containers should be packed with cotton in a larger box if shipped by mail.

Labeling

No matter what type of collection is made, each container, whether box, tube, or vial, should be labeled with station number, locality, date of collection, and name of collector. If the collection is of adults, note should be made of whether each container represents a biting record, a catch in a resting station, a light trap catch, or a sweep-net record.

STUDY TECHNIQUES

When the mosquito material, either larval or adult, is brought to the laboratory for study, the same care must be exercised in its further preparation as was expended in its collection.

Larvae

In most instances it is satisfactory to preserve larval material in alcohol. Diagnostic characters in most groups are seen readily on specimens in fluid.

For detailed studies of pecten and comb scales, a permanent mount is desirable. The larva should be dehydrated by being run through the alcohols to 95 per cent, cleared in benzol or cedar oil, and then mounted in Damar balsam. Each larva with an air tube should be cut through the seventh abdominal segment and the anterior portion mounted with the dorsum up and the posterior end with the left side up. This mounting will allow the study of the largest number of characters to best advantage. Pieces of broken slides should be placed around the specimen in such a way that they prevent the cover slip from flattening and distorting the specimen. When the air tube is flattened, its proportionate length to width becomes greatly distorted and cannot then be used as an accurate guide for identification.

Adults

Material brought in from the field should be mounted for study. A very satisfactory method of mounting is to glue the insects on card points. If the end of the point is crimped down quite a distance, and moderately thin cellulose cement is used for glue, a neat mount can be made with the dorsum of the specimen uppermost. Before being pinned, adult specimens should be relaxed for a short time. There is a tendency for the specimen to become greasy if relaxed too long, and care must be observed regarding this point. Full data labels should be put on every specimen.

Critical study of adult material frequently requires detailed examination of the genitalia. A preparation of the genitalia may be made as follows: snip or break off the posterior half of the abdomen and place it in a vial of 5 per cent caustic potash or caustic soda solution; heat the vial in a boiling water bath for about 5 minutes; remove the preparation from the caustic solution and place it in distilled water; press it gently with a needle to squeeze out dislodged viscera and brush it carefully to clean off lodged scales or dirt. Transfer the preparation to fresh, distilled water, leave it

there for 15 minutes to an hour, and then transfer it to 80 per cent alcohol that is very weakly acidulated with acetic acid. After leaving it in this solution for a few minutes, transfer it to a drop of glycerin in a well mount on a slide. The preparation is then ready for microscopic examination. For preservation, place the preparation in a very small vial, about 4 by 10 mm., which has a droplet of glycerin about 3 mm. deep in the bottom. Cork the vial and then push the pin, on which the insect is mounted, through the cork sidewise, as in fig. 10B.

In the case of heavily sclerotized genitalia, especially those of many *Aedes*, it is necessary to use a caustic solution of 10 or 15 per cent instead of 5 per cent.

For making large numbers of genital preparations simultaneously, it is convenient to use a battery of small vials of cold caustic solution. Good results with the more heavily sclerotized genitalia, such as those of *Aedes* and *Psorophora*, can be obtained with about 12 hours of clearing in cold 5 per cent caustic solution. For the more weakly sclerotized preparations, such as those of *Culex*, 5 or 6 hours of clearing are usually ample.

It is often necessary to tease apart various structures of the genitalia in order to see certain characters. For this purpose fine needles can be made from 00 insect pins. Snip off the head of the pin; then, holding the pin near the blunt end with pliers, force it bit by bit into a wooden handle whittled to suit the user. Large match sticks make fairly good handles for small needles.

REARING

Rearing is a necessary part of the mosquito study program. There are many instances in which the larvae, or the males or females, of two species cannot be differentiated, so that for final identification it is necessary to have associated larvae and adults. Two types of rearings are useful, individual rearings and group rearings.

Individual Rearings

A single larva is isolated in a vial or dish, about half full of water, and food is added until the larva matures. When it molts to form a pupa, its cast larval skin is immediately preserved in alcohol or mounted on a slide. At ordinary room temperatures the

pupa will mature in 3 or 4 days, and the adult will emerge. It is advisable to have some sticks or crumpled paper towel in the top of the dry part of the container so that the adult may rest there and harden for 2 or 3 days before being killed. Adults killed immediately upon emergence will shrivel. Frequently the adult can be transferred into a second container without free water and kept there for a few days to avoid the possibility of its drowning and disintegrating in the water. The pupal skin, larval skin, and adult should be preserved and mounted according to usual methods, and specimens of the same rearing associated by means of a distinctive accession number system. A convenient system is to use a lot number for each collection and a letter for each individual of this collection. For example, specimens from collection No. 157, bear the accession designations 157C, 157D, 157E, etc.; the adult bearing the label 157C is associated with a larval skin and a pupal skin also bearing the accession designation 157C. No other specimen or skin in the collection has on its label 157C. With this method, it is possible to avoid getting the skins and adults of different rearings mixed. Every skin and adult should be labeled *promptly and clearly*.

Group Rearings

In order to secure large numbers of study specimens in good condition, group rearings are of much use. Larvae may be placed in a large tube or mason jar and fed until they transform to pupae. For small cultures of less than 20 specimens, a cap vial about 1½ inches in diameter and 2 or 3 inches long is very satisfactory. After a culture has pupated, the container should be placed in a large dry-battery jar or cage having a tight muslin top, and a liberal amount of crumpled paper toweling placed in the bottom. The small container can be fastened upright on the inside of the large container by adhesive tape. After adults begin to emerge, water can be squirted through the muslin top onto the paper toweling, care being taken not to bathe the adults. This water will prevent desiccation of the adults and their premature death. In 2 or 3 days the adults will harden satisfactorily, and the entire cage can be treated with a fumigant to kill them. They may then be picked out of the cage and mounted.

Larval Food

If larvae are collected when almost ready to pupate, a supply of the water in which they have been breeding and some of the organic matter from the bottom of the same pond will provide ample food to carry them to full development. If, however, they are collected at an earlier stage, it is necessary to add food. The safest type of food is fresh material from the bottom of a pond; this may be added to the rearing containers every 2 or 3 days. If this food cannot be obtained conveniently, various prepared foods, such as crumbled yeast, powdered dog biscuit, moldy corn, and gold fish food can be substituted. Because there is great danger that these concentrated foods will putrefy in the water, resulting in bacterial growth that will kill the mosquito larvae, they should be used in minute quantities.

Temperature, Aeration, and Sunlight

If the rearing is done indoors in hot weather, death of the larvae may result from too high a temperature or from insufficient aeration. Larvae that normally live in a cold water environment should be kept relatively cold. It is desirable to keep jars containing such larvae in a running water bath. This will generally keep the temperature of the rearing medium below 75 degrees F. Good ventilation is necessary for indoor rearing of *Anopheles* larvae. Satisfactory results are obtained with these larvae by using rearing containers nearly filled with water and placed near or in an open window; for adult emergence the pupae should be transferred to containers with 2 or 3 inches of air space above the water. Some exposure to sunlight gives good results, but in the heat of summer this exposure must be short to avoid overheating the water.

CLASSIFICATION

Mosquitoes belong to the order Diptera, or two-winged flies and to the family Culicidae. This family is characterized by the following adult structures: antennae, figs. 32-38, filamentous and slender, with 15 segments, the first 2 forming the base and the last 13 forming the slender thread. Each segment has a whorl of hairs, which in the males are extremely long. The eyes are large and conspicuous. The mouthparts

consist chiefly of a proboscis (which may be either short and flabby, or elongate and forming a beak) and a pair of maxillary palpi; the palpi are referred to in this report as "palps." The legs are long and spindly. The wings are fairly large; radial sector is 3-branched and Media is 2-branched; the branches of radial sector are either nearly straight or only slightly curved. The family is divided into two subfamilies, the Chaoborinae, or non-biting mosquitoes, and the Culicinae, the true mosquitoes. An adult of the Chaoborinae is readily distinguished from all adult Culicinae because it does not have a beak; each adult of the Culicinae has a well-developed beak or proboscis. The larvae of some Chaoborinae, however, might be readily confused with the larvae of true mosquitoes.

Terminology

Many special terms are employed for distinctive parts of both adults and larvae of the mosquitoes, and these terms are used throughout the keys and descriptions. Fig. 12 is labeled to identify these distinctive parts of the larvae. Special parts of the

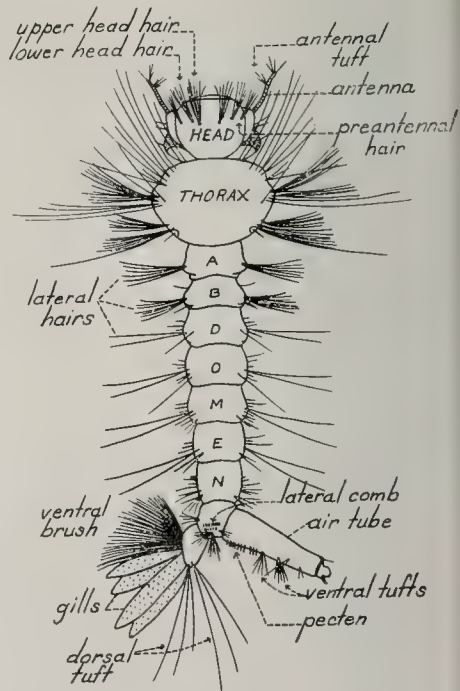


Fig. 12.—Larval diagram, Culicinae. (After King, Bradley, & McNeel.)

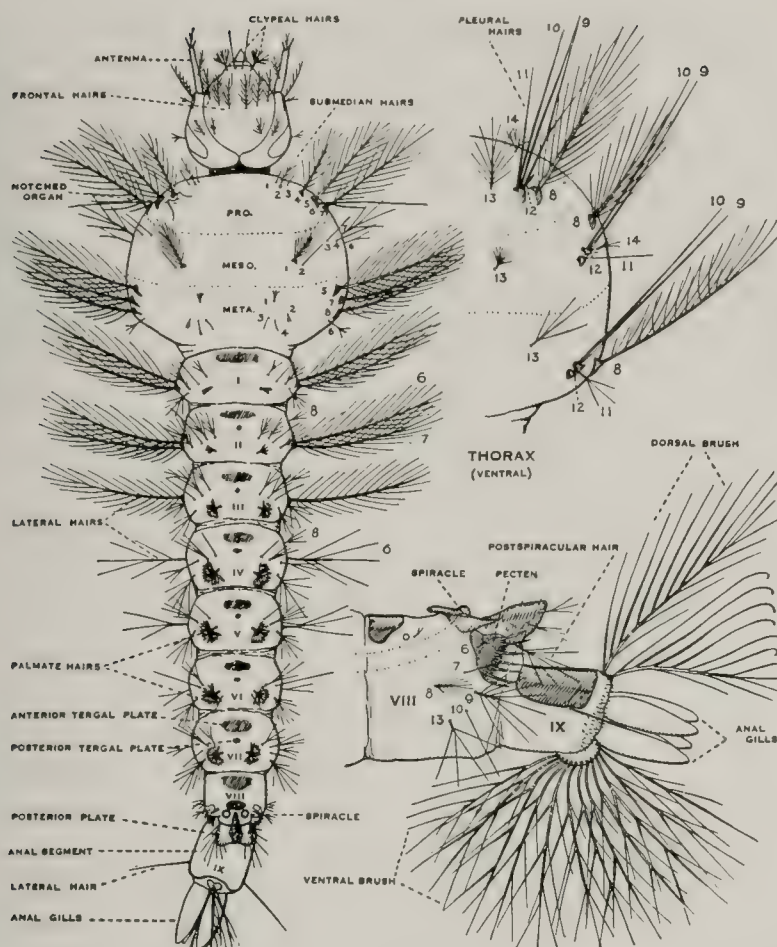


Fig. 13.—*Anopheles* larva. Left figure, dorsal view of entire larva; upper right figure, details of thorax; lower right figure, apex of abdomen, lateral aspect. (After Ross & Roberts, by courtesy of American Entomological Society.)

adults are identified on diagnostic drawings where they appear in the text associated with the keys. Distinctive structures of *Anopheles* larvae are shown in fig. 13.

Literature

Additional information about mosquitoes, especially species not contained in this report, will be found in the general mosquito reports listed below. Additional information concerning these reports is given in the section "Literature Cited." Papers of more limited scope are mentioned later in the text in reference to particular genera or species.

1928. *The Mosquitoes of the Americas*, by Harrison G. Dyar.

1937. *The Mosquitoes of Minnesota*, by William B. Owen.
1939. *The Mosquitoes of the Southeastern States*, by W. V. King, G. H. Bradley, and T. E. McNeel.
1941. *The Mosquitoes of Arkansas*, by Stanley J. Carpenter.
1942. *The Mosquitoes of Oklahoma*, by L. E. Rozeboom.
1944. *The Mosquitoes of Wisconsin*, by W. E. Dickinson.
1944. *Handbook of the Mosquitoes of North America*, by Robert Mathe-son.
1944. *The Mosquitoes of Texas*, by Texas State Health Department.
1946. *The Mosquitoes of the Southern United States*, by Stanley J. Car-

penter, Woodrow W. Middlekauff, and Roy W. Chamberlain.

Material Studied

The major part of the material on which this study is based was collected by staff members of the Insect Survey Section, Illinois Natural History Survey. Various other persons or organizations contributed much valuable material, and I am greatly indebted to them for permission to use their records in this paper. J. Lyell Clarke, Des Plaines Valley Mosquito Abatement District, Lyons, Illinois, and M. A. Dobbs and J. M. Gilbert, East St. Louis Health District, contributed extensive material. I wish to express my appreciation to officials of the Chicago Natural History Museum, who allowed me to study their mosquito collections; individual records from their material are marked in this paper with the initials CM. In addition, I am greatly indebted to officials of the U. S. Public Health Service and the Illinois State Department of Public Health for permission to use their extensive records of Illinois mosquitoes; these records are indicated in this paper by the abbreviation USPHS.

Acknowledgments

I wish to express my gratitude to several workers who were kind enough to check keys and to give advice on many questions which have arisen during the progress of this report. Captains C. F. Gerlach and F. Earle Lyman of the U. S. Public Health Service were very helpful in these matters. I am especially indebted to Dr. Alan Stone, U. S. Bureau of Entomology and Plant Quarantine, who was of the utmost assistance regarding the taxonomic problems which arose time and again. I wish to thank also the officers of the U. S. National Museum for the loan of considerable study material of critical species, especially larval material of rare *Aedes* species.

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Various individuals and organizations were extremely kind in either loaning drawings and cuts for use in this bulletin or in giving permission to reproduce illustrations appearing in their publications. On this score I am especially indebted to Professor Robert Matheson and the Comstock Publishing Company; the American Entomological Society; the Entomological Society of Washington; the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture; and the Malaria Control in War Areas, U. S. Public Health Service.

KEY TO SUBFAMILIES

LARVAE

1. Antennae arising close together on a mesal raised area or protuberance of the head, fig. 14. *Chaoborinae*
Antennae arising at sides of head, figs. 12, 13 2
2. Anal segment with a sclerotized ring or plate, figs. 17-20; antennae without long, prehensile hairs *Culicinae*
Anal segment without either a sclerotized ring or plate; antennae with long, prehensile hairs (*Mochlonyx* and *Eucorethra*), figs. 15, 16 *Chaoborinae*

ADULTS

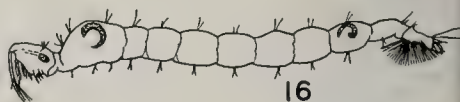
1. Proboscis elongate, figs. 32-38, many times longer than depth of head. . . . *Culicinae*
Mouthparts forming only short submembranous lobes which are no longer than depth of head. *Chaoborinae*



14



15



16

Fig. 14.—Head of larva of *Corethrella*.

Fig. 15.—Larva of *Mochlonyx cinctipes*. (Redrawn from Matheson.)

Fig. 16.—Larva of *Chaoborus punctipennis*. (Redrawn from Matheson.)

Subfamily CHAOBORINAE

The adults of this subfamily are midge-like; their bodies usually are hairy but without scales. Four genera comprise the North American fauna of the subfamily. Of these, *Chaoborus*, *Corethrella*, and *Mochlonyx* occur in Illinois; the fourth genus, *Eucorethra*, is widely distributed north of Illinois but has not yet been taken in the state. Larvae of *Chaoborus*, fig. 16, have no air tubes. Larvae of the other three genera have either air tubes (*Mochlonyx* and *Corethrella*) or spiracular plates of the *Anopheles* type (*Eucorethra*); in these genera the larvae are predaceous and in general appearance resemble those of some biting mosquitoes.

A synopsis of the North American species, together with keys and illustrations, is presented by Matheson (1944).

Subfamily CULICINAE

To date, 10 genera of this subfamily, representing the true mosquitoes, have been taken in Illinois. It should be emphasized that this mosquito group includes all the Culicidae with well-developed beaks, many species that bite, and in addition a few species that do not bite.

The subfamily Culicinae is frequently divided into two tribes, the Anophelini, including in the Illinois fauna only *Anopheles*, and the Culicini, including the other nine Illinois genera. However, the subfamily is sometimes divided into a large number of tribes. Since the final solution of this problem in taxonomy will require a study of the world fauna, the most practical solution for the present report has been to avoid segregation into tribes and to treat the subfamily as a single unit.

Mosquitoes of Illinois

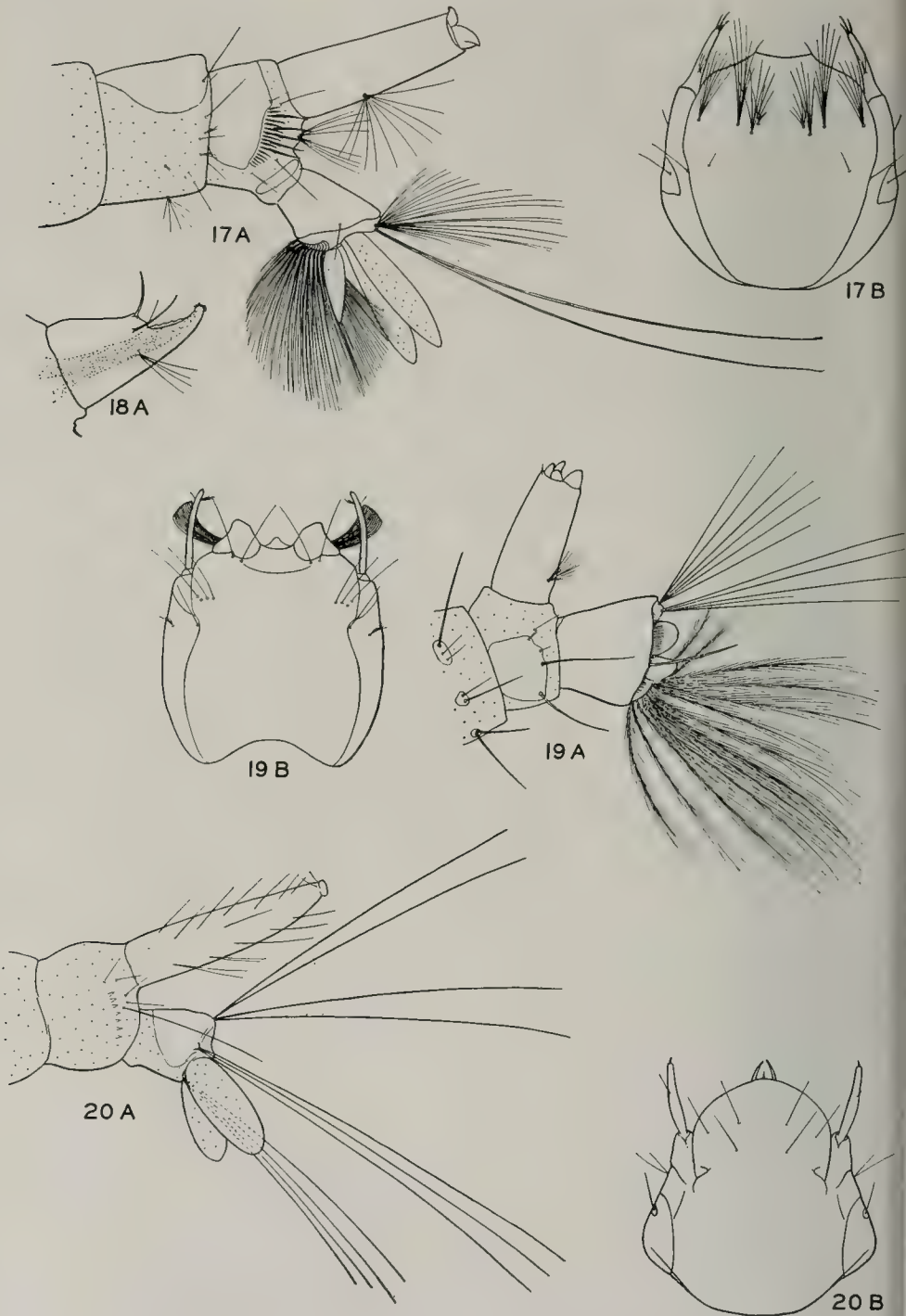
Aedes aegypti (Linnaeus)
Aedes aurifer (Coquillett)
Aedes canadensis (Theobald)
Aedes cinereus Meigen
Aedes dorsalis (Meigen)
Aedes dupreei (Coquillett)
Aedes excrucians (Walker)
Aedes fitchii (Felt & Young)
Aedes flavescens (Müller)
Aedes fulvus pallens E. S. Ross
Aedes grossbecki Dyar & Knab

Aedes implacabilis (Walker)
Aedes mitchellae (Dyar)
Aedes nigromaculis (Ludlow)
Aedes punctor (Kirby)
Aedes sollicitans (Walker)
Aedes spencerii (Theobald)
Aedes sticticus (Meigen)
Aedes stimulans (Walker)
Aedes thibaulti Dyar & Knab
Aedes triseriatus (Say)
Aedes trivittatus (Coquillett)
Aedes vexans (Meigen)
Anopheles barberi Coquillett
Anopheles crucians Wiedemann
Anopheles punctipennis (Say)
Anopheles quadrimaculatus Say
Anopheles walkeri Theobald
Culex apicalis Adams
Culex erraticus (Dyar & Knab)
Culex peccator Dyar & Knab
Culex pipiens Linnaeus
Culex quinquefasciatus Say
Culex restuans Theobald
Culex salinarius Coquillett
Culex tarsalis Coquillett
Culiseta inornata (Williston)
Culiseta morsitans (Theobald)
Mansonia perturbans (Walker)
Megarhinus septentrionalis Dyar & Knab
Orthopodomyia alba Baker
Orthopodomyia signifera (Coquillett)
Psorophora ciliata (Fabricius)
Psorophora confinnis (Arribáizaga)
Psorophora cyanescens (Coquillett)
Psorophora ferox (Coquillett)
Psorophora fescolor (Humboldt)
Psorophora horrida (Dyar & Knab)
Psorophora howardii Coquillett
Psorophora varipes (Coquillett)
Uranotaenia sapphirina (Osten Sacken)
Wyeomyia smithii (Coquillett)

KEY TO GENERA

LARVAE

1. Eighth segment with a flat spiracular plate, but no air tube, fig. 13. .1. *Anopheles*
 Eighth segment with an air tube, figs. 17-202
2. Air tube short, with some of its sclerites at the apex forming long stout spurlike processes, fig. 18.5. *Mansonia*
 Air tube without stout processes, its apical sclerites flat or conical, figs. 17, 19, 203
3. Ventral brush of anal segment represented by only an apical pair of double hairs, fig. 20.4. *Wyeomyia*



Larval parts: A, apex of abdomen; B, dorsum of head.

Fig. 17.—*Orthopodomyia signifera*.

Fig. 18.—*Mansonia perturbans* (the air tube only.) (After King, Bradley, & McNeel.)

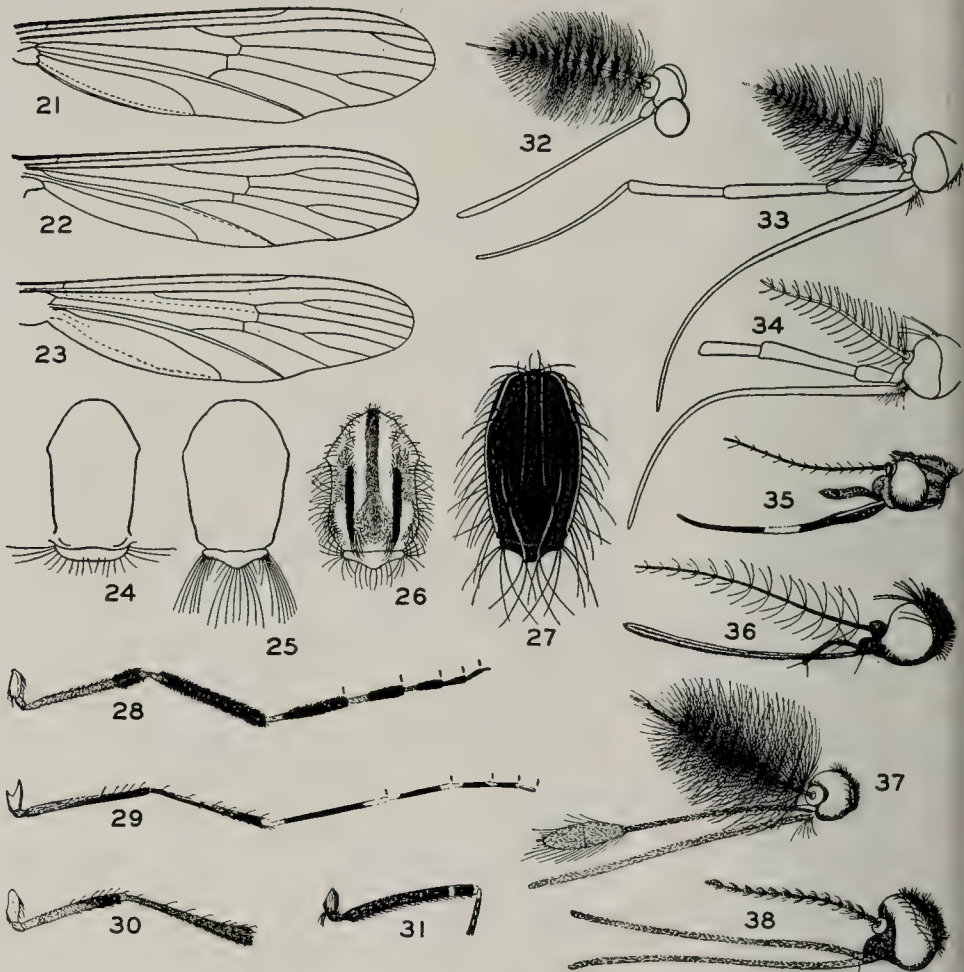
Fig. 19.—*Megarhinus septentrionalis*.

Fig. 20.—*Wyeomyia smithii*. Note ventral brush reduced to only four long hairs.

- Ventral brush of anal segment consisting of several tufts, figs. 17, 19.4
4. Anal segment with sclerotized plate not meeting ventrad, figs. 102-105. Many species of.9. *Aedes*
- Anal segment completely ringed by sclerotized plate, fig. 17.5
5. Air tube cylindrical and without pecten, figs. 17, 19.6
- Air tube either fusiform, fig. 175, or with a pecten, figs. 75, 98, 172.7
6. Abdominal segments 3-7 with three spine-bearing sclerotized plates on each side, fig. 19A; head quadrate, with stout mouth brushes and only a few single dorsal setae, fig. 19B.2. *Megarhinus*
- Abdominal segments 3-7 without lateral plates, sometimes segments 6 and 7 with dorsal saddle, fig. 17A; head oval, with fine bushy mouth brushes and with most of the dorsal setae multiple, fig. 17B.6. *Orthopodomyia*
7. Comb teeth situated on the posterior margin of a large sclerotized plate that covers most of the eighth segment; head with four stout black spines; fig. 72.3. *Uranotaenia*
- Comb teeth either on a small, poorly defined plate, fig. 172, or not on a plate; head with slender hairs, no stout spines, fig. 74.8
8. Air tube with a single pair of ventral tufts situated at base, figs. 74, 75.7. *Culiseta*
- Air tube either without ventral tufts, or with tuft near middle or apex, figs. 98-101, or with air tube having several pairs of tufts, figs. 80-85.9
9. Air tube with several pairs of ventral tufts of which some may be represented by single long hairs, figs. 79-85.8. *Culex*
- Air tube with only a single pair of ventral tufts, or with none.10
10. Ventral brush of anal segment having several tufts that arise out of the sclerotized ring, figs. 172-174.10. *Psorophora*
- Ventral brush of anal segment with all tufts situated posterior to sclerotized ring, fig. 111. Some species of.9. *Aedes*
- ADULTS
1. Fork of R_{2+3} close to margin of wing, cell R_2 only half length of its petiole, R_{2+3} , fig. 21.2
- Fork R_{2+3} much farther from margin of wing, so that cell R_2 is as long as its petiole, fig. 22.3
2. Beak curved almost into a quarter circle, palps of both sexes very long, those of female massive, figs. 33, 34; large species, wing length 6.5 mm.2. *Megarhinus*
- Beak only slightly curved, palps of both sexes short and abortive, fig. 32; small species, wing length under 3.5 mm.3. *Uranotaenia*
3. Mesoscutellum with apical margin evenly rounded, the setae arranged evenly along it, fig. 24; male with clavate palps, fig. 37, and female with palps as long as beak, fig. 38.1. *Anopheles*
- Mesoscutellum with apical margin incised to form a mesal lobe and two lateral lobes, with the setae grouped on these three lobes, fig. 25; male palps not clavate and female palps short, fig. 35.4
4. Mesonotum with a mesal line of short setae and scales, and with a wide, polished bare area along each side of the mesal line, fig. 26; hind femur with a tuft of projecting scales at apex, fig. 28. Large species of.10. *Psorophora*
- Mesonotum without linear, polished bare areas; hind femur with only a few projecting hairs at apex, fig. 30.5
5. Hind tarsi with one or two segments entirely white, the remainder entirely blue or black. A few species of.10. *Psorophora*
- Hind tarsi either with some segments banded, fig. 29, or all segments nearly the same color.6
6. Hind tarsi with wide or conspicuous bands of white on most segments, fig. 29.7
- Hind tarsi with no bands or with only inconspicuous ones.13
7. Second, third, and fourth tarsal segments each with a narrow white band at each end, fig. 29.8
- Second, third, and fourth tarsal segments each with a white band at base only, figs. 127-131.10
8. Beak black, with a definite white band in middle, as in fig. 35. The species *tarsalis* in.8. *Culex*
- Beak not banded, either all black, or mottled, or black with rows of white scales along its entire length.9
9. Mesonotum either without white lines, or generally cream in color as in fig. 119. A few species of.9. *Aedes*
- Mesonotum nearly black, with a series of white lines as in fig. 27.6. *Orthopodomyia*
10. Post-spiracular area entirely bare; hairs on disc of mesonotum long, abundant, and erect, fig. 39.5. *Mansonia*
- Post-spiracular area with bristles or a patch of scales; hairs on disc of pronotum much more appressed, fig. 41.11
11. Outer faces of hind femora in general dark but each with a transverse band of white scales near apex, fig. 31. A few species of.10. *Psorophora*
- Outer faces of hind femora without such bands.12

12. Wings with either Costa banded with white-scaled areas and black-scaled areas, or anal vein white scaled for basal two-thirds with apical portion black scaled. A few species of.....
10. *Psorophora*
 Wings either almost uniformly white or

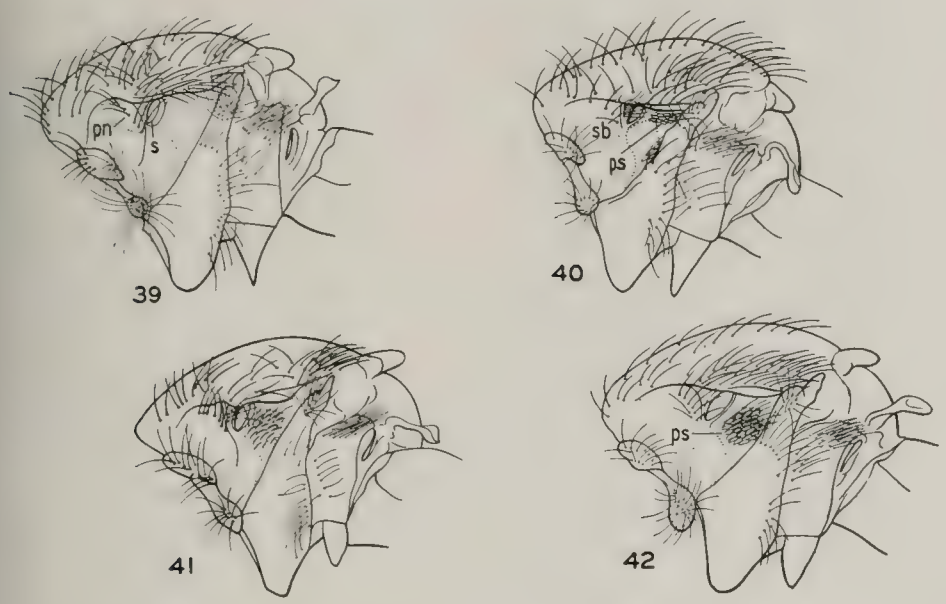
- dark scaled, or the two types of scales mingled in a salt-and-pepper, patternless mixture. Some species of.....9. *Aedes*
 13. Mesonotum covered with a close mat of blue-black scales, with bristles only around periphery; fork of R_{2+3} basad of fork of M_{1+2} , fig. 224. *Wyeomyia*



Adult Parts

- Fig. 21.—*Uranotaenia sapphirina*, wing.
 Fig. 22.—*Wyeomyia smithii*, wing.
 Fig. 23.—*Aedes vexans*, wing.
 Fig. 24.—*Anopheles quadrimaculatus*, mesonotum.
 Fig. 25.—*Aedes vexans*, mesonotum.
 Fig. 26.—*Psorophora ciliata*, mesonotum.
 Fig. 27.—*Orthopodomyia signifera*, mesonotum.
 Fig. 28.—*Psorophora ciliata*, hind leg.
 Fig. 29.—*Aedes canadensis*, hind leg.
 Fig. 30.—*Psorophora varipes*, portion of hind leg.

- Fig. 31.—*Psorophora confinnis*, hind femur.
 Fig. 32.—*Uranotaenia sapphirina*, male head.
 Fig. 33.—*Megarhinus septentrionalis*, male head.
 Fig. 34.—*Megarhinus septentrionalis*, female head.
 Fig. 35.—*Aedes sollicitans*, female head.
 Fig. 36.—*Orthopodomyia signifera*, female head.
 Fig. 37.—*Anopheles quadrimaculatus*, male head.
 Fig. 38.—*Anopheles quadrimaculatus*, female head.



Adult Thorax, Lateral Aspect. Abbreviations: *pn*, pronotal bristles; *ps*, post-spiracular bristles or scales; *s*, spiracle; *sb*, spiracular bristles.

Fig. 39.—*Mansonia perturbans*.
Fig. 40.—*Culiseta inornata*.

Fig. 41.—*Psorophora confinnis*.
Fig. 42.—*Aedes stimulans*.

- Mesonotum with several series of erect bristles extending above scales on disc, fig. 42; fork of R_{2+3} at about same level as that of M_{1+2} , fig. 23. 14
14. Mesonotum either with broad lateral bands or areas of white or cream scales, figs. 115, 120–123, or almost entirely covered with cream scales. 15
- Mesonotum mostly dark scaled, at most with a scattering of light scales, or with narrow weak lines of them. 16
15. Hind tibiae enlarged and shaggy toward apex, with setae not longer than width of tibia at apex, fig. 30; spiracular bristles usually present, fig. 41. A few species of. 10. *Psorophora*
- Hind tibiae slender to apex, not shaggy, often with a scattering of setae longer than width of tibia at apex, figs. 29, 125, 126; spiracular bristles absent. Many species of. 9. *Aedes*
16. Post-spiracular area bare, and spiracular bristles lacking, as in fig. 39. 8. *Culex*
- Thorax either with post-spiracular area having bristles or scales, fig. 42, or spiracular bristles present, fig. 40, or both. 17
17. Spiracular bristles present; post-spiracular area sometimes with scales but never with hairs, fig. 40. 7. *Culiseta*
- Without spiracular bristles; post-spiracular area with hairs or hairs and scales, fig. 42. Many species of. . . . 9. *Aedes*
- MALE GENITALIA
1. Dististyle with a contorted mass of branches, fig. 46. 4. *Wyeomyia*

Dististyle either unbranched, fig. 43, or with only one or two simple lobes, figs. 133, 178. 2

2. A pair of subcylindrical arms (claspettes) arising from dorsum of capsule, and tipped with a sclerotized filament, figs. 136–158. Most species of. . . 9. *Aedes*

Claspettes absent, platelike, fig. 70, or each tipped with a cluster of spines, fig. 177. 3

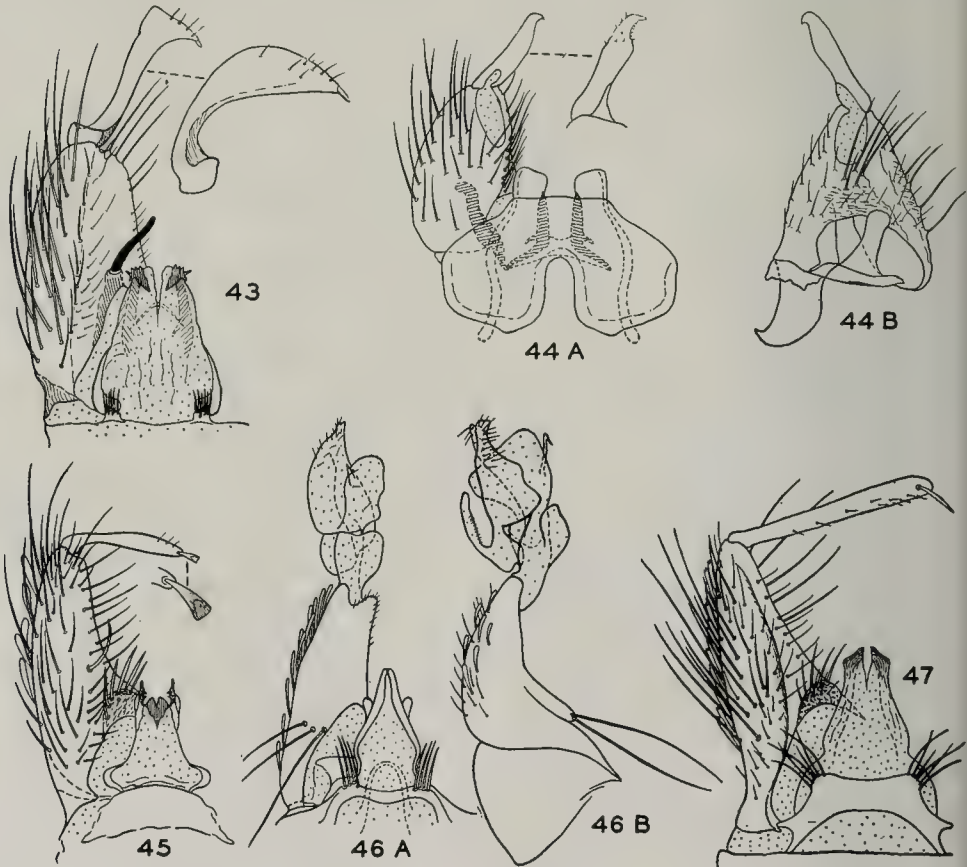
3. Dististyle bilobed, its mesal margin bearing a long hook and a large membranous lobe, fig. 178. The species *howardii* in. 10. *Psorophora*

Dististyle without an accessory membranous lobe. 4

4. Basistyle with an apico-mesal shoulder bearing a cluster of specialized, blade-like or spatulate spines, which are frequently complex in structure, figs. 88–95. 8. *Culex*

Basistyle either without an apical shoulder, or the shoulder bearing only narrow spines. 5

5. Apex of basistyle continuing as a pointed lobe beyond insertion of dististyle, fig. 135. The species *cinereus* in.....9. *Aedes*
Dististyle situated at apex of basistyle, fig. 43.....6
6. Dististyle with a pointed lobe projecting beyond apical spur, fig. 133. The species *vexans* in.....9. *Aedes*
Dististyle with apical style terminal, fig. 45, or apex round, fig. 47, or truncate, fig. 180.....7
7. Claspettes each with a stalklike base, and with a comblike cluster of spurs or setae at apex, figs. 177, 179-182; dististyle sinuate, fig. 177, or bulbous, figs. 179-182. Most species of...10. *Psorophora*
- Claspettes absent or platelike, fig. 70, dististyle of various shapes.....8
8. Basistyle with a stout peglike rod on mesal face near middle; dististyle with apical half very wide, its apical seta forming a stout spurlike tip, fig. 43.....5. *Mansonia*
Basistyle frequently with one or more stout setae on mesal face, but never with a rodlike structure; dististyle either not enlarged at apex or with a peglike or hairlike apical seta, figs. 45, 47.....9
9. Basistyle short and ovate, with a pair of large, stout spines dominating the ventral aspect of the basal portion, fig. 70.....1. *Anopheles*
Basistyle either long and slender, fig. 45,



Male Genitalia

Fig. 43.—*Mansonia perturbans*, ventral aspect, and lateral aspect of dististyle.

Fig. 44.—*Uranotaenia sapphirina*; A, ventral aspect, with lateral aspect of dististyle; B, mesal aspect of clasper, with mesosome and other mesal structures removed.

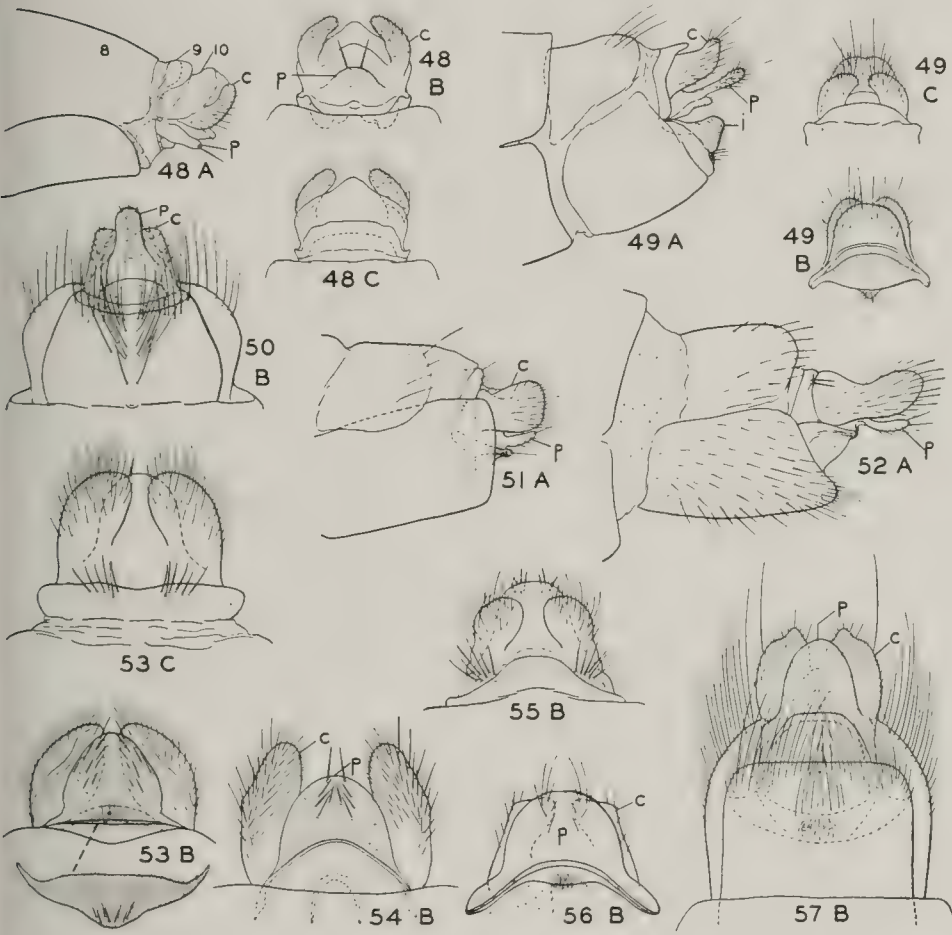
Fig. 45.—*Orthopodomyia signifera*, ventral aspect.

Fig. 46.—*Wyeomyia smithii*; A, ventral aspect; B, lateral aspect.

Fig. 47.—*Megarhinus septentrionalis*, ventral aspect.

- or without a pair of isolated stout spines on basal portion of ventral aspect, fig. 4410
13. Ninth tergite forming a large bilobed sclerotized plate whose lateral lobes are nearly as long as the basistyle, fig. 44.3. *Uranotaenia*
- Ninth tergite forming at most a plate as wide as in fig. 47.11
11. Apical seta of dististyle single, slender, and pointed at tip, figs. 47, 134.12
- Apical seta of dististyle short and either divided, fig. 78, or truncate at tip, fig. 4513

12. Base of basistyle with a mesal, arcuate pad bearing a crown of stout spines; dististyle cylindrical, with apical spine just before apex, fig. 47.2. *Megarhinus*
- Base of basistyle without a mesal pad; dististyle tapering toward apex, apical spine issuing from tip, fig. 134. The species *aegypti* in.9. *Aedes*
13. Apical spine of dististyle double, each ray short and stout; mesosome without lateral teeth at apex, fig. 78.7. *Culiseta*
- Apical spine of dististyle cone shaped, wide and truncate at apex, and with what appears to be a minute fringe



Female Genitalia: A, lateral aspect; B, ventral aspect; C, dorsal aspect. Abbreviations: c, cercus; p, postgenital plate; i, insula plate.

- Fig. 48.—*Anopheles quadrimaculatus*.
Fig. 49.—*Uranotaenia sapphirina*.
Fig. 50.—*Wyeomyia smithii*.
Fig. 51.—*Mansonia perturbans*.
Fig. 52.—*Orthopodomyia signifera*.
Fig. 53.—*Culiseta inornata*.
Fig. 54.—*Culex restuans*.
Fig. 55.—*Culex apicalis*.
Fig. 56.—*Culex erraticus*.
Fig. 57.—*Megarhinus septentrionalis*.

along the edge; mesosome with a few short, lateral teeth at apex, fig. 45....
.....6. *Orthopodomyia*

FEMALE TERMINALIA

1. Cerci round and finger-like, wide apart and directed almost dorsad, fig. 48....
.....1. *Anopheles*
Cerci either closer together, or leaflike and directed posterad, figs. 49-57.....2

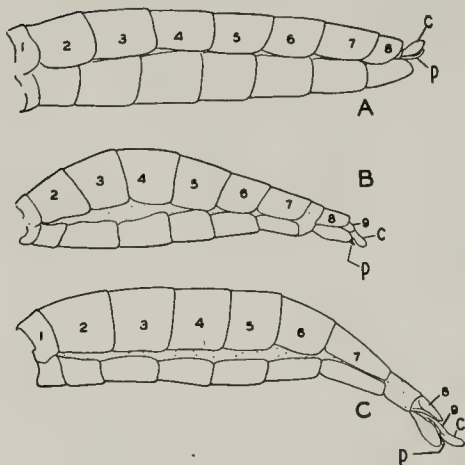


Fig. 58.—Abdomen of adult female, lateral aspect. A, *Culiseta inornata*; B, *Aedes aegypti*; C, *Psorophora ciliata*. Abbreviations: c, cercus; p, postgenital plate.

2. Eighth segment retractile, markedly narrower than seventh and joined to it by a wide band of membrane, figs. 58B, C; cerci either long and narrow, fig. 159, or extending far beyond postgenital plate, fig. 160.....3
Eighth segment not retractile, practically the same diameter as the seventh, joined to it by a narrow strip of membrane, fig. 58A; cerci short and extending little if at all beyond end of postgenital plate, figs. 49-57.....4
3. Ninth tergite consisting of a fairly wide, indefinitely outlined rectangular dorsal sclerite, figs. 159-167.....9. *Aedes*
Ninth tergite consisting of a heavily sclerotized, longitudinal rod enlarged at apex and extending basally beneath eighth tergite, fig. 184.....10. *Psorophora*
4. Postgenital plate extending considerably beyond cerci, fig. 50.....4. *Wyeomyia*
Postgenital plate extending only slightly if at all beyond cerci, fig. 49.....5
5. Eighth tergite long and wide, forming a flat hood that extends considerably beyond sternite; ninth segment and cerci

flattened and horizontal, fig. 57.....

-2. *Megarhinus*
Eighth tergite hemicylindrical, shorter than sternite and not at all hoodlike, figs. 49, 52.....6
6. Cerci with base enlarged, middle constricted, and apex expanded, fig. 52....
.....6. *Orthopodomyia*
Cerci with base not at all enlarged, but sometimes expanded at apex, fig. 51.....7
7. Insula plate well developed as a sclerotized, arcuate, cushion-like crescent, fig. 49; ninth tergite with apical margin rounded and sclerotized, slightly overhanging base of cerci.....
.....3. *Uranotaenia*
Insula plate either entirely membranous or forming a band that bears a small mesal tuft of setae, fig. 53.....8
8. Cerci from edge to edge almost vertical in position, the apex markedly widened; eighth sternite nearly twice length of eighth tergite, fig. 51.....5. *Mansonia*
Cerci from edge to edge inclining to horizontal in position, the apex narrowed at least slightly, fig. 53; eighth sternite longer than eighth tergite, but not as much longer as in *Mansonia*.....9
9. Postgenital plate parallel sided and truncate, with a long apical seta near each corner and many small setae on the central area, fig. 161; ninth segment narrow. A few species of.....9. *Aedes*
Postgenital plate rounded or pointed, with a row or cluster of several scattered setae near apex, fig. 54; ninth segment wide.....10
10. Postgenital plate very wide, as in fig. 56.....8. *Culex*
Postgenital plate much narrower, figs. 53-55.....11
11. A U-shaped internal sclerite present in membranous folds of spermatheca, fig. 54.....8. *Culex*
No distinct internal sclerite evident in folds of spermatheca, fig. 55.....12
12. Ninth tergite forming a sclerotized, fairly straight bridge, with a pair of clusters of setae situated close together, fig. 53.....7. *Culiseta*
Ninth tergite consisting of irregular folds at most semisclerotized, with clusters of setae situated far apart near lateral margins, fig. 55.....8. *Culex*

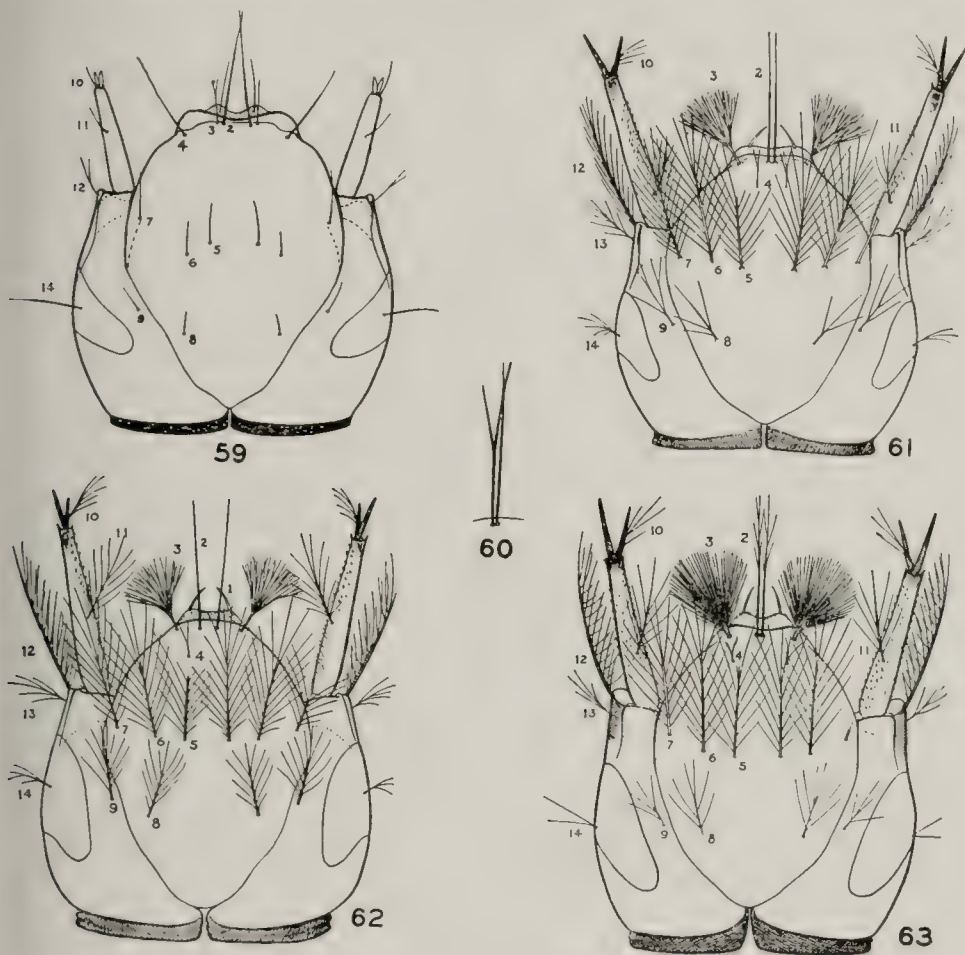
1. *ANOPHELES* Meigen

Of the Illinois mosquitoes, *Anopheles* is the most distinctive genus and the most important one. The larvae, fig. 13, are readily distinguished by the platelike aper-

ture of the breathing apparatus, which in all other Illinois mosquito larvae is tubular; the adults have the scutellum evenly rounded, not trilobed, and the males have the apical segments of the palps greatly enlarged, fig. 37. According to present information, *Anopheles quadrimaculatus* is the chief carrier of malaria in Illinois.

In proportion to their size, few mosquito genera present so many difficulties regarding larval identification as the North American *Anopheles*. There is undoubtedly much variation within many of the species, both

in the hair arrangement of the larvae and in the details of the male genitalia. Consequently, in Illinois the main basis for identification of the species in this genus should be the adult females. In other sections of the country the larvae may present the only reliable characters for certain complexes of the species. Many keys have been presented for the identification of males by means of the genitalia. The studies of Roth (1944), however, have substantiated my own observation that the characters of the male genitalia can be used only on an average basis



Heads of *Anopheles* Larvae

Fig. 59.—*A. barberi*. (After Ross & Roberts.)

Fig. 60.—*A. occidentalis* (inner clypeal hairs only).

Fig. 61.—*A. punctipennis*. (After Ross & Roberts.)

Fig. 62.—*A. quadrimaculatus*. (After Ross & Roberts.)

Fig. 63.—*A. walkeri*. (After Ross & Roberts.) Hair numerals used on this plate are those currently employed in the taxonomic literature on mosquitoes.

and cannot be used as a means of absolute diagnosis in all cases.

The recent work of Ross & Roberts (1943) and Roth (1944) illustrates extensively many diagnostic and other structural features of this genus. Additional descriptions and a summary of distribution is given by King & Bradley (1941), and biological material by Bradley & King (1941). An interesting study of variation in larval characters has been made by Roth (1945b).

To date, five species of this genus have been taken in Illinois. A sixth, *occidentalis*, has been taken in Iowa across the Mississippi River from Illinois. As it undoubtedly occurs in Illinois, it has been included in the key.

KEY TO SPECIES

LARVAE

1. Head hairs 5, 6, and 7 short and simple, fig. 59; lateral body hairs with only short feathering.....1. *barberi*
Head hairs 5, 6, and 7 long and plumose, fig. 61; lateral hairs of thorax and first

- three abdominal segments with long feathering, fig. 64.....2
2. Fourth and fifth abdominal tergites with hairs 0 and 2 plumose, fig. 65.....5. *crucians*
Fourth and fifth abdominal tergites either with hairs 0 inconspicuous or with hairs 2 only single or double, fig. 64.....3
3. Head hairs 3 very dense, fan shaped from base, so that no basal stalk is evident, fig. 63; head hairs 2 sometimes feathered at tip; prothoracic hairs 1 sometimes branched.....3. *walkeri*
Head hairs 3 less dense, the fan shaped portion beginning some distance from base so that a basal stalk is formed, fig. 61; head hairs 2 never feathered at tip; prothoracic hairs 1 rarely branched...
.....4
4. Second abdominal segment with hairs 1 well developed, sclerotized and palmate, fig. 64.....2. *quadrimaculatus*
Second abdominal segment with hairs 1 small, at most fanlike, fig. 65, not at all like the palmate hairs on segment 3..5

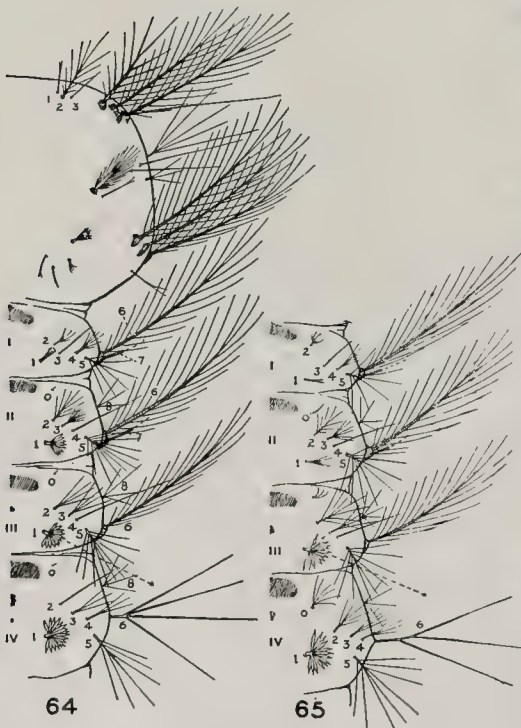
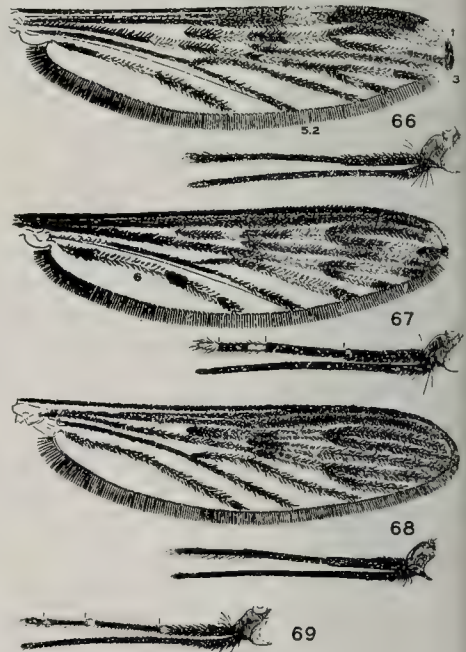


Fig. 64.—*Anopheles quadrimaculatus*, larva, portion of dorsum.

Fig. 65.—*Anopheles crucians*, larva, portion of dorsum.



Parts of *Anopheles* Adults

Fig. 66.—*A. puncticornis*, wing and mouthparts.

Fig. 67.—*A. crucians*, wing and mouthparts.

Fig. 68.—*A. quadrimaculatus*, wing and mouthparts.

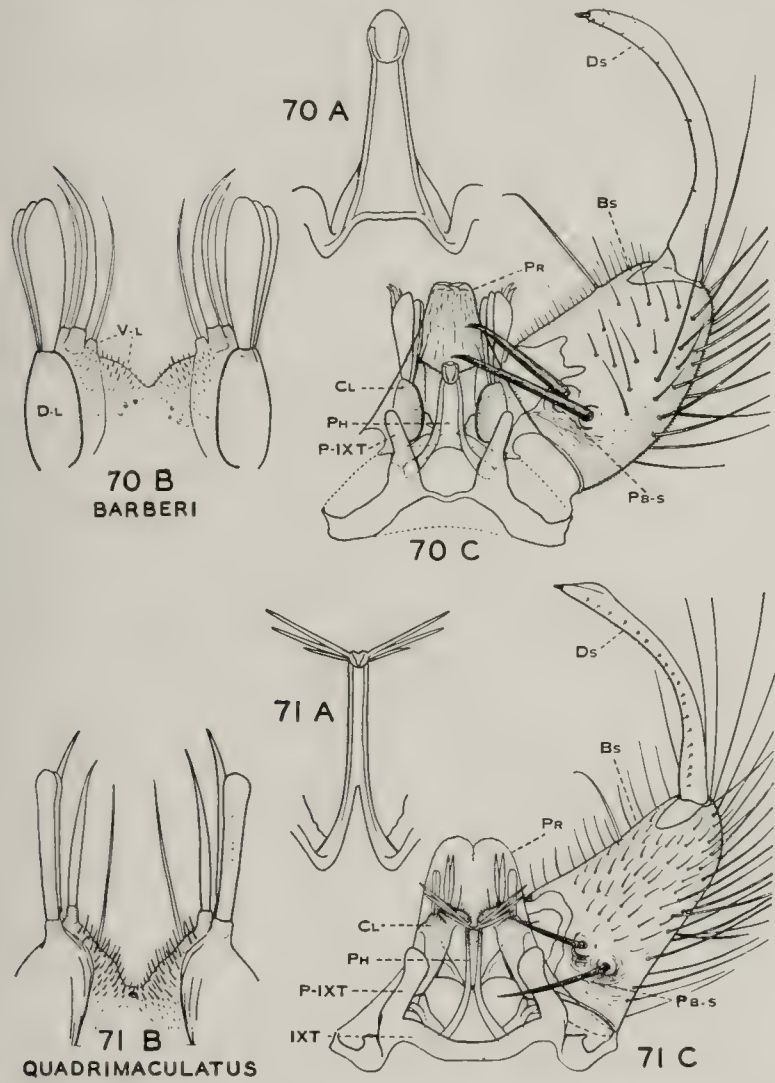
Fig. 69.—*A. walkeri*, mouthparts. (Figs. 64–69 after Ross & Roberts.)

5. Head hairs 2 wide apart, fig. 62.....
.....2. **quadrिमaculatus**
Head hairs 2 close together, fig. 61.....6
6. Head hairs 2 always simple, fig. 61.....
.....4. **punctipennis**
At least one of the two head hairs 2 usually
with a conspicuous branch, fig. 60...
.....**occidentalis**

ADULTS

1. Wings with spots or bars of white or yellowish-white scales along anterior margin and anal vein, figs. 66, 67.....2

- Wings without any pale patches, all scales dark, fig. 68, except sometimes apical fringe hairs.....3
2. Anal vein with 3 short dark bars separated by white bars; palps dark with white bands, fig. 67; Costa with a white spot only at apex of wing...5. **crucians**
Anal vein with apical half and extreme base black, and with a single white area between; palps black, unbanded, fig. 66; Costa with an apical white spot and usually also a preapical spot or bar...
.....4. **punctipennis**



Figs. 70-71.—Male genitalia of *Anopheles*. A, phallosome; B, claspette; C, ventral aspect of entire structure. Abbreviations: Bs, basistyle; CL, claspette; Ds, dististyle; IXT, ninth tergite; Pbs, parabasal spine; Ph, phallosome; P-IXT, process of ninth tergite; Pr, proctiger. (After Ross & Roberts.)

3. Tip of wing with a patch of silvery or golden fringe scales; dark wing spots very pronounced. *occidentalis*
Tip of wing with fringe not different from remainder; dark wing spots frequently obscure 4
4. Palps narrow and filiform, fig. 38 (females) 5
Palps enlarged into an oval apical club, fig. 37 (males) 7
5. Palps black, with white rings, fig. 69 3. *walkeri*
Palps entirely black, without rings, fig. 68 6
6. Wings without a trace of spotting; wing length about 3.5 mm. 1. *barberi*
Wings with definite darker areas giving a spotted appearance, fig. 68; wing length about 5.0 mm. 2. *quadrimaculatus*
7. Mesosome without leaflets at apex, fig. 70; wing length under 3.5 mm. . . 1. *barberi*
Mesosome with a cluster of leaflets at apex, fig. 71; wing length over 3.5 mm. 8
8. Lobes of ninth tergite stout, apex wide, sometimes enlarged, fig. 71 2. *quadrimaculatus*
Lobes of ninth tergite narrower, usually tapered at apex 3. *walkeri*

1. *Anopheles barberi* Coquillett

LARVA.—Fig. 59. Length 6 mm. Head with almost all hairs simple and unbranched, especially conspicuous being hairs 3, 5, 6, and 7. Thorax and abdomen with only short feathering on lateral major hairs. Segments 3-7 with a pair of palmate hairs, segment 2 with moderately developed palmate hairs. Pecten consisting of an irregular series of long teeth, each tooth with serrations at base.

FEMALE.—Wings with veins having almost uniformly dark scales, neither the field of the wing nor the fringe with dark spots or light patches.

MALE.—Similar in color and general structure to female. Genitalia, fig. 70, with two large parabasal spines; mesosome tapered, without apical leaflets; claspettes with three setae on the ventral lobe and three broad scales arising in a compact group from the dorsal lobe.

This species contains the smallest individuals of *Anopheles* in North America, mosquitoes that in general appearance are easily confused with small dark *Culex* individuals. The setation of the larvae and structures of the male genitalia separate this species indu-

bitably from all other North American anophelines.

It has been found in only a few of the many tree holes investigated and is either much more critical in its choice of breeding place or much less abundant than several other tree hole species such as *Aedes triseriatus*. As pointed out by King, Bradley, & McNeel (1939), this species has been proved susceptible to malaria parasites but is of doubtful importance in malaria transmission. It is widely distributed in the southern and eastern states.

ILLINOIS RECORDS.—Six larvae, collected June 29 to July 6, and many males and females, collected May 25 to October 10, are from Alton (USPHS), Cahokia (USPHS), Camp Ellis (USPHS), Cartersville (USPHS), Crab Orchard Lake (USPHS), Des Plaines, East Alton (USPHS), East St. Louis, George Field (USPHS), Hampshire (USPHS), Johnston City (USPHS), Marion (USPHS), Momence, Mount Vernon (USPHS), Onarga, Savanna (USPHS), Scott Field (USPHS), and Springfield (USPHS).

2. *Anopheles quadrimaculatus* Say

LARVA.—Fig. 62.—Length 8 mm. Head with hairs 2 long, simple and widely separated; hairs 3 plumose, branching some distance from base; hairs 5, 6, and 7 long and plumose. Thorax and first three segments of abdomen with long feathering on lateral major hairs. Abdominal segments 4 and 5 with hairs 2 usually single, rarely double; of the total of four "hair 2's" on segments 3 and 4, seldom is more than one double. Palmate hairs on segments 3 to 7, frequently also on segment 2. Pecten with a series of well-spaced long teeth, between each of which is a group of three or four short teeth. Body hairs shown in fig. 64.

FEMALE.—General color dark brown. Palps entirely dark brown to black, with no annulations. Wings, fig. 68, uniformly dark scaled, the scaling slightly darker at the fork of R_{2+3} , M_{1+2} , the base of R_s and the base of R_{4+5} . These darker scalings make four dark spots, sometimes very pronounced, sometimes scarcely perceptible.

MALE.—Similar in color and general structure to female. Genitalia, fig. 71, with two large parabasal spines; mesosome slender, its apex with a group of three leaflets on each side; claspettes each with setae of dorsal lobe round at tip, those of ventral lobe sharp and pointed. The number of setae on each lobe varies considerably; if

only two or three are present on the dorsal lobe, they may fuse at the tip.

The diagnosis of this species is clear cut only in the female. The separation of the larvae of this species from those of *punctipennis* is frequently difficult. Nearly all the specimens I have seen from Illinois will key out without difficulty, but an occasional larva is encountered that falls squarely between the two alternatives of couplet 5. In our series of associated larval skins, there is considerable variation in the branching of hair 2 on abdominal segments 4 and 5; the more reliable character seems to be the distance apart of head hairs 1. The males are extremely close to those of *walkeri*, although in all of our specimens the separation on the lobes of the ninth tergite is fairly satisfactory. The halteres of *quadrimaculatus* are usually much darker than those of *walkeri*, but these characters vary somewhat, and, in preserved specimens, the difference tends to disappear with time.

In Illinois, the breeding season of *quadrimaculatus* begins nearly a month after that of *punctipennis* in the south and of *walkeri* in the north, indicating a restriction imposed by water temperature. The preference for warmer water is further suggested by the abundance of *quadrimaculatus* in more open and still bodies of water during the heat of the summer when *punctipennis* is found only in more heavily shaded or markedly cooler waters. The habitat preference of *quadrimaculatus*, which is quite wide, includes small pools, backwaters, and shallow basins of large lakes and marshes. Abundant populations of larvae are almost always associated with emergent vegetation, ranging from plants such as *Jussiaea diffusa*, which never extends more than a few inches above the water surface, to cattails, rushes, and shrubs reaching a height of several feet. We have a few records of *quadrimaculatus* living in running water, but these were in situations where the water was shallow and warm, and the flow extremely sluggish.

Biting records indicate that the females are crepuscular and nocturnal. On cloudy days we have noticed a tendency for the females to bite early in the afternoon, but normally they bite no earlier than shortly before dusk. Their bites are seldom painful and often go unnoticed.

This species is considered the most important carrier of malaria in the United States east of the Rocky Mountains.

Illinois Records.—Many larvae, collected June 2 to October 1, and many males and females, collected May 16 to November 15, are from Algonquin, Antioch, Belleville (USPHS), Benton, Bonnie, Cahokia (USPHS), Cairo (USPHS), Camp Ellis (USPHS), Camp Grant (USPHS), Carbondale, Carterville (USPHS), Caseyville, Champaign, Chanute Field (USPHS), Charleston, Crab Orchard Lake (USPHS), Danville (USPHS), Decatur (USPHS), Detroit, Dubois, Dwight (USPHS), East Alton (USPHS), East Hannibal, East Moline (USPHS), East Peoria (USPHS), East St. Louis, Edgemont, Edwardsville, Elgin, Elsah, Evansville, French Village (USPHS), Galesburg (USPHS), George Field (USPHS), Gibson City (USPHS), Gibsonia, Glendale, Gorham, Grafton (USPHS), Grand Tower, Granite City (USPHS), Hampshire (USPHS), Havana, Hecker, Herod, Herrin, Hull, Johnston City (USPHS), La Rue, Lawrenceville (USPHS), Makanda (USPHS), Marion (USPHS), Milford (USPHS), Mississippi Palisades State Park, Momence, Mound City (USPHS), Mount Vernon (USPHS), Mulberry Grove, Oakwood, Olive Branch, Olney, Omaha, Palos Park, Pere Marquette State Park, Port Byron, Rockford (USPHS), Rock Island (USPHS), St. Jacob, St. Joseph, Savanna, Scott Field (USPHS), Seneca (USPHS), Springfield (USPHS), Starved Rock State Park, Thomson, Urbana, Ursa, Vienna, Waltersburg, and Ware.

3. *Anopheles walkeri* Theobald

LARVA.—Fig. 63. In size and general color similar to *quadrimaculatus*. General structure of head and body as described for *quadrimaculatus*, except for the following differences: head hairs 2 close together, in our Illinois specimens almost always single and very long, rarely with one or two fine branches near tip. Abdomen sometimes with well-developed palmate hair on segment 2, segments 4 and 5 with hair 2 usually single and very long, rarely double or triple. The best diagnostic character found to date is head hair 3, which is densely branched from the base and therefore lacks a basal stalk.

FEMALE.—In color similar to *quadrimaculatus* with the exception of the palps, fig. 69, which are black with a narrow white annulation at each joint. The wing spotting is identical with that of *quadrimaculatus*.

MALE.—Genitalia very similar to those of *quadrimaculatus*, differing in the more slender lobe of the ninth tergite; usually the ventral lobe of the claspette has only one stout and one slender seta.

It is noteworthy that the diagnostic characters for the larvae of this species, which have been stressed by King & Bradley (1941) and by Ross & Roberts (1943), are not applicable to Illinois specimens. Following are characters listed by these authors and, in parentheses, my own observations on Illinois specimens: head hair 2 finely branched at tip (only an occasional Illinois specimen has these hairs branched and then with only one or two branches); prothoracic hair 1 branched (this hair is usually single in Illinois specimens); and hair 0 distinct and many branched (in only a rare Illinois specimen is hair 0 discernible). The densely tufted head hair 3, however, is an excellent diagnostic character, our associated larval skins indicate. This same character is well illustrated by Ross & Roberts.

This species is abundant in the marshes of extreme northeastern Illinois. Outside of this area we have Illinois records from only three widely separated localities, all from the Mississippi River valley region. These three localities are Savanna and nearby Thomson (the northwestern corner of the state), East Hannibal (almost at the center on the western margin), and Scott Field (a short distance south of the St. Louis area). All our collections have been made in cattail marshes, to which this species appears to be restricted. In the northeastern corner of the state this species is found in practically every marsh and bog in which cattails are found. The larvae have never been found there in abundance. Collecting which nets one larva per five dips is unusual; usually the proportion is closer to one larva per 20 dips. The marshes, however, are very extensive in this section, and the species is quite abundant. Unlike the females of *quadrimaculatus*, the *walkeri* females bite readily during the day as well as during the evening. In early summer they are especially vicious and will attack a person in bright sunlight.

In northeastern Illinois, adults and full grown larvae have been collected early in June and also late in October. The species has a great tolerance for cool water and is similar to *A. punctipennis* and *Culiseta inornata* in this respect.

It is interesting to note that *walkeri* is considered rare south of northern Illinois. In northern Illinois and northward, it is one of the dominant species of the anopheline populations, as shown by our Illinois collec-

tions and by studies in Minnesota and Wisconsin by Daggy, Muegge, & Riley (1941).

Illinois Records.—Larvae, taken May 19 to September 15, and many males and females, collected May 19 to November 1, are from Antioch, Beach, Camp Grant (USPHS), Cary, East Hannibal, Fox Lake, Franklinville, Great Lakes Naval Training Station, Lake Bluff, Lake Zurich, Orland Park, Savanna (USPHS), Scott Field (USPHS), Thomson, Volo, Wauconda, Waukegan, Woodstock, and Zion.

4. *Anopheles punctipennis* (Say)

LARVA.—Fig. 61. Length 8 mm. Color and general conformation of hairs on head and body as for *quadrimaculatus*. Diagnostic characters as follows: head hairs 2 long and single, the pair close together at base; head hairs 3 each with multiple branching that begins some distance from the base, so that the base of the hair forms a distinct stalk; palmate hair of second abdominal segment reduced; abdominal segments 4 and 5 with hairs 2 usually double, occasionally single or triple, the single, double, or triple hairs occurring in almost any combination on different specimens.

FEMALE.—Body dark brown, with the mesonotum clothed with grayish scales and the wings definitely patterned with dark and cream color. Palps entirely dark without white annulations. Typical wing pattern, fig. 66, having a white costal patch near apex and a preapical white patch one-third the distance between apical spot and base of wing, this preapical spot including adjacent portions of C, R₁, and R₂₊₃; in addition there are variable areas of white scales near the base of R₅ and M, M₁₊₂, M₃, and M₄; a diagnostic and stable area of white scales occupies most of the basal half of the anal vein.

MALE.—General structure and color, especially wing pattern, as for female. Genitalia in general as for *quadrimaculatus* with the following average differences in the claspette: dorsal lobe usually with only one seta, which may be round or pointed at apex; ventral lobe usually with only one stout and one narrow seta in addition to one or two short setae.

Occasional larvae are found that seem to bridge the gap between *punctipennis* and *quadrimaculatus*. The number of such larvae, however, appears so small as to be of no statistical importance in proportional

counts because 99 per cent of all the larvae taken can be identified with certainty.

Extreme variation of wing pattern has been found in Illinois material of this species. Two wing spots appear to be constant, the apical costal spot and the white bar on the base of the anal vein. All the other spots vary greatly, and occasionally additional white bars appear on practically all the radial and medial veins. The pre-apical spot is subject to the most conspicuous variation. Usually it is about one-half as long as the dark bar separating it from the apical spot. In the light extremes, the pre-apical spot may be fully as long as this dark bar; in dark extremes the preapical spot may be only a quarter or a sixth as long as the bar; and in rare instances no preapical spot may be present. Our collections indicate that there is no particular significance to these variations. We have taken a wide range of these types in a single collection from one locality, and seldom does a large collection from one locality present even a reasonable homogeneity in regard to wing spots.

In Illinois, *punctipennis* is undoubtedly the most widespread and common species of *Anopheles*. It breeds in a wider variety of aquatic situations than the other species in the genus. We have taken it in running streams, backwaters of lakes, cattail marshes, densely wooded cypress swamps, and open and practically barren pools. In southern Illinois, it is the earliest anopheline to make its appearance, the first adults usually emerging by about the middle of April. In the northern part of the state, mature larvae and pupae have been collected in the middle of October. In early spring it shows a preference for open sunlit water. In the heat of summer, at least in southern Illinois, it leaves the open situations almost entirely and breeds in fairly densely shaded situations, such as pools and creek beds, running streams, cypress swamps, or woodland pools. Both seasonal distribution and habitat indicate a preference for cooler water than that frequented by *quadrimaculatus*. In the northern part of the state this segregation is not so pronounced; here *punctipennis* and *quadrimaculatus* are frequently taken together in the same body of water.

Although *punctipennis* is extremely widely distributed, it has never been found in the tremendous local abundance that characterizes populations of *quadrimaculatus*. Evi-

dence at present indicates that *punctipennis* is not an important carrier of malaria under natural conditions, although the species becomes infected readily under experimental conditions.

Illinois Records.—Many larvae, collected May 14 to October 14, and many males and females, collected April 17 to November 29, are from Albion, Algonquin, Belleville (USPHS), Brubaker, Cache, Cahokia (USPHS), Cairo, Calvin, Camp Ellis (USPHS), Camp Grant (USPHS), Carbondale, Carterville (USPHS), Champaign, Chanute Field (USPHS), Charleston, Council Hill, Crab Orchard Lake (USPHS), Decatur (USPHS), Dixon Springs, Dwight (USPHS), East Alton (USPHS), East Moline (USPHS), East Peoria (USPHS), East St. Louis, Edwardsville, Effingham, Elsah, Epworth, Florence, Forest Glen, Fox Lake, Fox Ridge State Park, French Village (USPHS), Fulton (USPHS), Galesburg (USPHS), George Field (USPHS), Giant City State Park, Gibson City (USPHS), Gorham, Gossett, Grafton (USPHS), Grand Tower, Granite City (USPHS), Grantsburg, Greenville, Grimsby, Hamilton, Havana, Herod, Herrin, Joetta, Johnston City (USPHS), Jonesboro, Kankakee, Karnak, Keithsburg, Laclede, La Grange, Lake Villa, La Rue, Lawrenceville (USPHS), Lima, Maroa, Marion (USPHS), McClure, Michael, Mill Shoals, Mississippi Palisades State Park, Momence, Mount Carmel, Mount Vernon (USPHS), Mulberry Grove, Muncie, Neoga, New Athens, New Haven, Nutwood, Oakwood, Oak Park, Olney, Omaha, Palos Park, Pere Marquette State Park, Pingree Grove, Pittsburg, Pittsfield, Quincy, Richmond, Ridge Lake, Rising Sun, Rockford (USPHS), Rock Island (USPHS), Rockton, St. Jacob, St. Joseph, Salem, Savanna (USPHS), Scott Field (USPHS), Seneca (USPHS), Springfield, Starved Rock State Park, Sugar Grove, Thomson, Urbana, Ursa, Utica, Viola, Waltersburg, Ware, Waterloo, Wauconda, White Heath, White Pines Forest State Park, Willow Springs, Wolf Lake, and Zion.

5. *Anopheles crucians* Wiedemann

LARVA.—Fig. 65. Color, size, and general conformation of hairs on head and body as for *quadrimaculatus*. Diagnostic characters as follows: head hairs 2 long and single, the pair close together at base; head hairs 3 each with multiple branching that begins some distance from base, so that the base of the hair forms a distinct stalk; palmate hair of second abdominal segment reduced; abdominal segments 4 and 5 with hairs 0 and 2 multiple and conspicuous.

FEMALE.—Body dark brown, the mesono-

tum clothed with linear areas of grayish scales, and the wings patterned with dark and cream color. Palps dark, with the short apical segment white and with a conspicuous white band at the base of the third segment. Typical wing pattern, fig. 67, having the costal margin entirely dark scaled except for a white patch at the apex of the wing; in addition there are areas of white scales on all the veins posterior to R_1 ; a diagnostic feature is the alternation of white and dark-scaled areas on the anal vein.

MALE.—General structure and color, especially wing pattern, as for female. Genitalia very similar to those of *punctipennis* males.

In Illinois this species has been taken in numbers only in the St. Louis area and southward. Two apparent stragglers have been taken north of this area, one at Havana and one at Peoria. The species is widespread south of Illinois, and our records represent probably the northern edge of its range.

Our only larval records are from cattail marshes in the Mississippi River valley. In an extensive cattail marsh at La Rue, Illinois, this species was especially abundant. The larvae were taken in company with those of *quadrifasciatus*, which outnumbered the *crucians* larvae almost two to one. Light trap collections indicate that *crucians* is never a dominant feature of the mosquito fauna in Illinois.

ILLINOIS RECORDS.—Many larvae, collected May 22 to October 1, and many males and females, collected June 16 to October 4, are from Alton (USPHS), Cache, Cahokia (USPHS), Carterville (USPHS), Crab Orchard Lake, East Alton (USPHS), East St. Louis, Granite City (USPHS), Havana, Herrin, Johnston City (USPHS), La Rue, Marion (USPHS), Mount Vernon (USPHS), Peoria (USPHS), and Scott Field (USPHS).

2. *MEGARHINUS* Robineau-Desvoidy

Individuals of this genus are among the most peculiar in the state. The adults are large and brilliantly colored. The proboscis is markedly curved, as in figs. 33 and 34, not adapted for biting but for feeding on nectar. The larvae as well as the adults are very large and may be identified immediately by the small sclerotized plates upon which many body setae are situated. The larvae are restricted to tree holes, in which they are predaceous upon other mosquito

larvae. According to previous workers, the eggs are laid singly on the surface of the water.

Only a single species, *septentrionalis*, has been taken in Illinois. The only other Nearctic species, *rutilus* Coquillett, is very closely allied and has never been collected north of the extreme southeastern United States.

1. *Megarhinus septentrionalis*

Dyar & Knab

LARVA.—Fig. 19. Head quadrate, with well-developed mouth brushes; antennae very short, with only one or two minute setae; dorsum of head with only a few minor setae. Body hairs long and stout, each segment of thorax with one sclerotized plate bearing the dorsal lateral tuft and another bearing the ventral lateral tuft. Segments 1–7 of the abdomen with the long seta situated on tubercle-like sclerotized plates, the first segment with four on each side, the remaining segments with three, each bearing one to several long setae. Eighth abdominal segment with a large lateral sclerite bearing several long apical setae and representing the lateral comb. Air tube short and stout, with a pair of ventral tufts near base. Anal segment large, completely enclosed in a heavily sclerotized ring, and having short budlike gills and hair tufts as in fig. 19.

FEMALE.—Length of wing 7 mm. Body and appendages with metallic iridescent scales. Palps and beak a mixture of bluish-purple and gold scales, dorsum of head greenish. Mesonotum with lateral and mesal stripes of greenish gold, the intervening bands black, purple, and green. Dorsum of abdomen almost entirely greenish purple, apical segments with a few lateral patches of silvery scales; venter almost entirely creamy gold, with a mesal greenish-purple stripe. Legs, for the most part, purplish; the middle and hind tarsi with the second, third, and fourth segments white; the hind tarsi with the fourth and fifth segments white; the femora with the base and posterior face of each mostly cream. Wings entirely purple scaled. The female genitalia are dorso-ventrally compressed, fig. 57, and in this respect the species is quite unlike any other Illinois mosquito group.

MALE.—In size and general color similar to female. The tarsi are black, except for the fourth segment of the hind tarsi, which

is clothed with dirty white scales. The palps are very long and black, fig. 33. Male genitalia, fig. 47, fairly simple in general structure, resembling in many respects those of *Culiseta*; differing most markedly in the shape of the dististyle and ninth tergite.

We have only a few scattered records of this species, all from the southern third of the state. Our records from Carbondale are based on captures of free-flying adults; specimens from Scott Field and Edwardsville were collected as immature stages in tree holes in oak-hickory woods. The species has been reported as widespread throughout the southeastern states.

Illinois Records.—CARBONDALE: Aug. 7, 1927, 1 ♀; 1941, 2 ♂; EDWARDSVILLE: Sept. 24, 1943, from tree hole, 1 ♀; SCOTT FIELD: Aug. 13, 1942, tree hole, 2 larvae; Aug. 24, 1942, fallen-tree hole, 1 ♂; Sept. 16, 1942, tree hole, 1 larva.

3. *URANOTAENIA* Arribáizaga

Individuals in this genus are small. Both adults and larvae present a number of distinctive characters that set them off readily from other mosquitoes in Illinois. Of the three species of *Uranotaenia* known to occur in North America, only one has been taken in Illinois.

1. *Uranotaenia sapphirina* (Osten Sacken)

LARVA.—Fig. 72. Length 5 mm. Head elongate, the upper and lower head hairs represented by long stout spines. Antennae short with a few sharp spines at apex. Thorax and first two segments of abdomen with long stout lateral hairs, abdominal segments 3–7 with only fine tufts of hairs. Lateral comb of eighth segment represented by a large sclerotized plate bearing a row of 8 to 10 teeth on its apical margin. Air tube elongate and slender, the pecten distinct and containing about 15 spines, the ventral tuft large and situated at the end of the pecten. Anal segment longer than deep, completely encircled by the sclerotized ring, the anal gills finger-like, slender, but only about as long as the anal segment.

FEMALE.—Length of wing 2.5 mm. Palps minute and budlike. Head and thorax, including beak, dark-brown scaled; dorsum of head, antero-lateral lobe of pronotum, patches of scales on the pleurae, a narrow line on the extreme edge of the mesonotum,

and a narrow mesal line down the pronotum, from near the anterior margin to the tip of the scutellum, bright iridescent blue. Abdomen dark brown with irregular apical patches of dirty white scales at the apex of some segments. Legs dark brown, each with a small conspicuous knee patch and a small patch on upper side of tip of tibia, each patch consisting of a cluster of white scales. Wings brown scaled, except for a line of blue scales covering the stem of Cubitus. All the brown scales of the wings and legs are iridescent, appearing greenish blue in certain lights.

MALE.—Similar in size and general structure to female; in this sex also the palps are small and budlike, fig. 32. Genitalia, fig. 44, with basistyle short and robust and with a cluster of five or six longer spines on the mesal face; dististyle short, the apex narrowed and hooked, without conspicuous apical seta. Ninth tergite developed into a very large bilobed plate that extends over the tenth segment and mesosome.

The larvae of this species, which is widespread in Illinois, live in permanent or semi-permanent ponds, preferring weed-choked situations. In northern Illinois they occur in several cattail marshes and in southern Illinois are usually associated with dense marginal growths of *Jussiaea*, especially

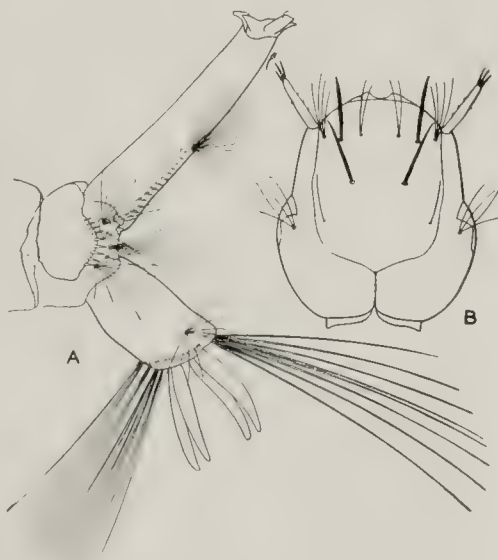


Fig. 72.—*Uranotaenia sapphirina*, larva. A, apex of abdomen, lateral aspect; B, dorsum of head.

where this plant occurs in combination with cattails or other marsh plants. They are very much like anopheline larvae in peculiarities of movement when diving or coming to the surface. The species appears fairly late in the season, apparently in response to the warmer waters of the summer season. The adults apparently do not bite. Presumably they feed on nectar. The females lay eggs in irregular rafts on the surface of the water.

This species has a wide range that embraces most of the United States east of the Great Plains and has at least scattered records from Minnesota to the extreme southern states. It has been reported from southern Illinois by both Chandler (1920) and Matheson (1930) and from various localities in the Chicago area by Gerhard (1910).

Illinois Records.—Larvae, collected June 3 to August 27 and many males and females, collected May 23 to October 21, are from Cahokia (USPHS), Cairo (USPHS), Camp Grant (USPHS), Carterville (USPHS), Chanute Field (USPHS), Charleston, Crab Orchard Lake (USPHS), East Hannibal, East St. Louis, Edwardsville, Effingham, Elgin, Elsah, Fox Lake, Fox Ridge State Park, Gibsonsia, Gossett, Grafton (USPHS), Granite City (USPHS), Great Lakes Naval Training Station, Havana, Hecker, Herod, Herrin, Homer, Johnston City (USPHS), Lake Glendale, La Rue, Marion (USPHS), Mount Carmel, Mount Vernon (USPHS), Muncie, Oakwood, Omaha, Ottawa, Peoria (USPHS), Putnam, Raymond, Salem, Savanna, (USPHS), Scott Field (USPHS), Seneca (USPHS), Springfield (USPHS), Starved Rock State Park, Sugar Grove, Thomson, Urbana, Volo, Wauconda, and White Pines Forest State Park.

4. *WYEOMYIA* Theobald

This genus is represented in Illinois by only the pitcher plant mosquito, *smithii*. The males are readily identified by the curious shape of the dististyle, fig. 46. The larvae, fig. 20, have very distinctive characters in the structures of the terminal segments.

1. *Wyeomyia smithii* (Coquillett)

LARVA.—Fig. 20. Length 6 mm. Head longer than wide, somewhat ovate, antennae short, without conspicuous lateral tufts. Dorsum of head with only a few indistinct hairs. Body hairs very long. Eighth segment with a lateral comb consisting of about eight scales arranged in a straight

row. Air tube small, slender, with about 15 pairs of long single hairs scattered along its length. Anal segment almost ringed by the sclerotized plate. The apex of this plate bears dorsally two pairs of long double hairs and a single pair of lateral double hairs; at the postero-ventral corner of the plate is a pair of double or triple hairs. No ventral brush is present. The anal gills, two in number, are large and sausage shaped; a second pair of gills may be represented by a pair of small swellings above the base of the conspicuous gills.

FEMALE.—Length of wing 3 mm. Beak, dorsum of head, mesonotum, and dorsum of abdomen almost uniformly covered with a mat of iridescent bluish-black scales. Pleurae and venter uniformly covered with creamy or silver scales. Scales of mesonotum forming a dense appressed mat without setae projecting above it, but with setae projecting from beneath it at the sides and along the posterior margin. Postnotum with a small cluster of minute setae. Legs, for the most part, blue black, whitish blue beneath, iridescent; the middle pair may have the apical two or three segments predominately white scaled, at least on the outer face. Wings uniformly deep bluish-brown scaled.

MALE.—Similar in size, color, and structure to female. The palps are short and abortive as in female. The male genitalia, fig. 46, have a long slender basistyle and are distinguished from those of all other Illinois mosquitoes by the curious processes of the dististyle.

In Illinois this little mosquito is found only in the tamarack bogs of the northeastern corner of the state. The larvae live in the water contained in the pitchers of the pitcher plant, *Sarracenia purpurea* Linnaeus. The species overwinters as larvae in the pitcher plants, and the adults emerge the following summer. The females, which lay eggs in the pitchers, apparently do not bite. The adults are quite active during the day, flying around the pitcher plants. They are very difficult to follow in flight; they have an irregular and slow flight pattern that combines with the gangling legs and iridescent color to make it difficult for an observer to be sure just how far away they are. The development of the larvae is apparently very slow. In this respect the pitcher plant mosquito resembles the tree hole species.

The range of the species includes most of

the northeastern states, wherever the pitcher plant occurs. Two other species in the genus occur in southern Florida. A key to the females is given by Roth (1946).

Illinois Records.—CEDAR LAKE: in bog, Aug. 3-6, 1906, Shobe, 3 ♀; Aug. 6, 1906, 1 ♂; Aug. 7, 1906, 7 ♂, 22 ♀. MCHENRY: Nov. 10, 1927, in pitcher plant, H. H. Ross, 3 larvae. VOLO: in pitcher plant, July 1, 1942, Ross & Mohr, 3 larvae; July 3, 1942, Ross & Mohr, 15 larvae; July 8, 1942, Ross & Mohr, 2 ♀, 2 pupal skins; July 19, 1942, Ross & Mohr, 12 ♂, 1 ♀; Oct. 27, 1943, Ross & Sanderson, 1 ♂.

5. *MANSONIA* Blanchard

Modifications in the larva make this genus of unique interest. The larval air tube forms a sharp piercing structure that is inserted into the roots or underwater stems of vascular plants; it pierces the air chambers of these, and the larva draws on the air in these chambers for its respiration. Thus, the larva does not need to come to the surface for air. Otherwise the larva and the adult are very similar to those of allied mosquitoes. The eggs are laid as rafts on the surface of the water. A single species, *perturbans*, occurs in Illinois. The only other United States species are the tropical *titillans* (Walker) and *indubitans* Dyar & Shannon, which are found in southern Florida (Pratt 1945). The species *perturbans* is placed in the subgenus *Coquillettidia* Dyar.

1. *Mansonia perturbans* (Walker)

LARVA.—Fig. 73. Head wider than long, antennae slender and long, with a fan-shaped tuft near middle; dorsum of head with many multiple tufts. Thorax and abdomen with many long setae. Eighth segment with an irregular row of scales forming the comb. Air tube, fig. 18, with a wide base, the apical sclerites long and sharp, forming a stout piercing organ. Anal segment fairly narrow, completely encircled by a sclerotized ring; anal gills pointed, shorter than segment.

FEMALE.—Length of wing 4.5 mm. Beak with a mixture of brown and pale scales, the latter forming an indistinct central ring. Dorsum of head and mesonotum with brown scales and hair, the mesonotal setae abundant, long and recurved. Abdomen with a mixture of pale and brownish-blue scales, the former predominating at the base of the

segment, the latter predominating at the apex. Femora and tibiae with an irregular mixture of brown and pale scales, the posterior face of femora chiefly cream scaled; tarsal segments 2-5 each having the basal half white scaled, the apex black scaled; basitarsi with a narrow basal band of white scales and an irregular central band of white scales. Wings with an indiscriminate mixture of white and brown scales, the scales all broad.

MALE.—In size, color, and general structure similar to female. Palps longer than beak, the apex of the second segment and the entire third and fourth segments with a ventral brush. Genitalia, fig. 43, with ninth tergite strap shaped and having a pair of conspicuous ventral lobes. Basistyle fairly stout, its mesal face with few setae and with a single long stout beaklike spine. Dististyle twisted and angulate at base, narrow, expanded, and bladelike at apex, its apical spine forming a stout sharp tip. Lobes of tenth sternite moderately long and evenly toothed. Mesosome short and stout, with a row of stout but minute dorsal teeth.

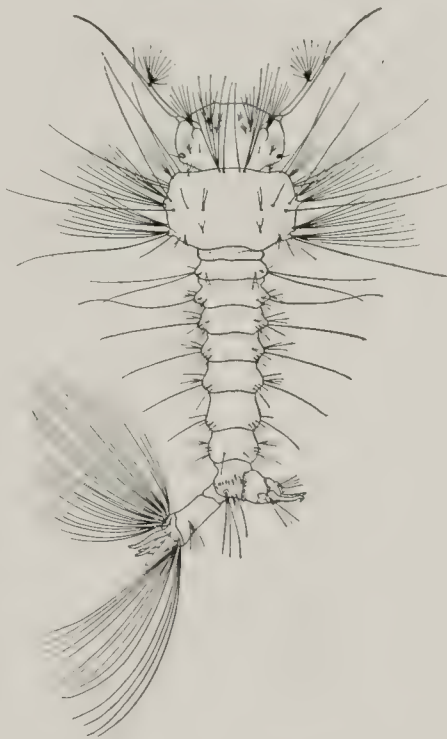


Fig. 73.—*Mansonia perturbans*, larva. (After Matheson.)

Taken in only a few areas of the state, this species is most commonly encountered in the marshes of the extreme northeastern corner and south to the Chicago area. A few other records have been taken extending to the southern third of the state. Adult records occur from June through August. Males have been taken only in the early part of this period and suggest that there is only a single generation per year in Illinois. The species is associated chiefly with cattails and aquatic sedges. In the southern states, pickerelweed, arrowhead, and other plants are frequently preferred for larval attachment.

The females are voracious biters, especially in the cloudy afternoons and the crepuscular periods.

Gerhard (1910) recorded this species as common and annoying in tracts of woodland in the Chicago region and encountered rarely on the south side of the city. Specimens from Roxana, Danville, and also Algonquin were recorded by Matheson (1930). J. Lyell Clarke has told me of occasional swarms of this species which were very annoying to the workers in several industrial plants on the south side of Chicago.

The species is widely distributed throughout the eastern United States, from Minnesota to Florida.

Illinois Records.—Adults, collected May 21 to September 19, are from Algonquin, Beach, Belleville (USPHS), Cahokia (USPHS), Camp Grant (USPHS), Carterville (USPHS), Danville, East St. Louis, Elsah, Grand Tower, Granite City (USPHS), Great Lakes Naval Training Station, Herrin, Johnston City (USPHS), Marion (USPHS), Oak Park, Peoria (USPHS), Pere Marquette State Park, Roxana, Savanna, Starved Rock State Park, Volo, and Zion.

6. *ORTHOPODOMYIA* Theobald

The Illinois species of this genus are characterized by the curious mesonotal pattern of the adults, fig. 27, and by the air tube, basal sclerite, and anal segment of the larva, fig. 17. Two species are known from Illinois, both of which occur only in tree holes. The status of these two species is very puzzling. To date no distinguishing characters have been discovered either in coloration of the external areas or in the structure of the male genitalia. The larvae, however, differ quite markedly both in color and in the average sclerotization of the seventh and eighth abdominal segments. Larvae of both

species are practically identical in chaetotaxy and formation of the lateral comb.

It has been suggested that the color of the base of the abdomen would separate these two forms in the adult stage. Isolated rearings have demonstrated that this difference does not hold, at least for Illinois specimens. It is therefore impossible at present to give a key for the specific diagnosis of males or females.

KEY TO LARVAE

- Head medium to dark brown, body pink; segments 6, 7, and 8 usually with dorsal sclerotized plates, the plate of segment 8 frequently extending ventrad to the ventral margin of the comb, fig. 17; these sclerotized plates may be entirely absent. 1. *signifera*
Head capsule very pale yellow to white, body white to straw color; segments 6, 7, and 8 without sclerotized plates. 2. *alba*

1. *Orthopodomyia signifera* (Coquillett)

LARVA.—Fig. 17. Length 7 mm. Head dark brown, somewhat oval, slightly longer than wide; upper and lower head hairs multiple and fan shaped, the lower hairs close to the uppers and more laterad than anteriad; between them is a pair of shorter fanlike tufts. Thorax and abdomen with many long hairs. Seventh abdominal segment frequently with a large dorsal sclerotized shield, which may be reduced to a pair of small dorsal sclerites or even be entirely absent. Eighth segment usually with a large dorsal sclerotized shield; this may be so large that it extends to the ventral end of the lateral comb but it may be much smaller or in rare individuals practically absent. Lateral comb consisting of two distinct series of scales, an anterior row of 15 to 20 small scales and a posterior row of about 5 very large long scales. Air tube about three times as long as wide, having no pecten but having a large ventral tuft just before middle. Anal segment with a basal barlike sclerite, the main portion of the segment completely surrounded by the sclerotized ring and with pointed gills, the upper pair much longer than the segment, the lower pair about as long as the segment.

FEMALE.—Length of wing 4 mm. Entire body principally dark brown to black scaled, dull and velvety. Beak and palps with irregular rows of white scales, dorsum of head

with scattered white scales and a prominent row around posterior margin of eyes. Mesonotum with narrow but sharp lines of white scales, fig. 27. First abdominal tergite and base of second usually white scaled. Femora with a scattering of white scales, tibiae with irregular lines of white scales. Tarsi black, the anterior pair with a minute white patch at end of basitarsus, the middle pair with patches of white at base of apex. Basitarsus and the hind pair with basal apical patches on the first four tarsal segments and on the dorsum of the last segment. The white bands on only the first two tarsal segments of the hind legs are wide enough to form conspicuous bands. Wings with a conspicuous mottling of white scales that form definite patches on the base of the anal vein and around the point where R_{2+3} and R_{4+5} divide from each other.

MALE.—Size, color, and general structure essentially as for female. Palps elongate, as long as beak, black scaled, without tufts, but apical segment with 15 or 20 fairly long stiff setae projecting irregularly on all sides. Male genitalia as in fig. 45. Ninth tergite mostly membranous, without definite ventral lobes. Tenth sternite of medium length, ending in a series of three or four closely appressed teeth. Mesosome about as long as tenth sternite, with short lateral teeth near apex. Basistyle elongate, with a ventral mesal cluster of stout setae; at its base is a mesal arcuate lobe that bears an even cluster of stout setae. Dististyle slender and elongate, tipped with a short stout seta that is truncate at apex, the end apparently with a cone-shaped hollow.

Widely distributed over Illinois, this species breeds exclusively in tree holes. The eggs are laid singly at the water's edge and hatch in a few days. As seems true with all the tree hole mosquitoes occurring in this latitude, the larvae apparently grow rather slowly. Emergence of adults begins toward the end of June and continues through the summer. Apparently females of the species bite humans only on rare occasions and are not a pest. Superficially the adult resembles the yellow-fever mosquito, *Aedes aegypti*. The adults can usually be found most readily sitting in and around tree cavities.

The species is widely distributed throughout many of the eastern states, although it does not occur much farther north than Illinois.

To date, all but one of the larval colonies of this genus that we have encountered in Illinois have been those of *signifera*. For this reason we have tentatively considered all field-collected adults of *Orthopodomyia* to be of this species.

This species was reported from the Chicago area by Gerhard (1910) as *Bancroftia signifera* and from Urbana by Matheson (1930).

ILLINOIS RECORDS.—Larvae, collected June 29 to July 3, and adults, collected June 5 to September 30, are from Cahokia (USPHS), Des Plaines, East St. Louis, Galesburg, Glencoe, Havana, Mahomet, Onarga, Ridge Lake, Scott Field (USPHS), Thebes, and Urbana.

2. *Orthopodomyia alba* Baker

Similar to *signifera* in adult characters and in general characteristics of the larva; differing as outlined in the key. Only a single colony of this species has been encountered in Illinois. It was found in a tree hole—in a soft maple tree at Onarga, where it occurred with *signifera*. This dual colony has persisted for several years, the *alba* larvae slightly more abundant than the *signifera* larvae. Individual rearings from this colony established the similarity in color of the adults of the two forms.

7. *CULISETA* Felt

Only two species of this genus have been taken in the state. A third species, *melanura* (Coquillett), is widespread to the east and south. The few remaining species of the genus are northern or western in distribution. The eggs are laid in rafts on the surface of the water. The adults resemble large specimens of *Culex*, but the larvae are readily distinguished from other mosquito larvae by the large basal tuft on the air tube.

KEY TO SPECIES

LARVAE

- Tube short and stout, fig. 74. 1. *inornata*
Tube longer and slender, fig. 75. 2. *morsitans*

FEMALES

- Tarsi without pale rings on the segments. 1. *inornata*
Tarsi with faint whitish rings at both ends of the segments. 2. *morsitans*

MALES

- Mesosome consisting of a pair of long, slender black rods tipped with a small membranous piece, fig. 78. 1. *inornata*

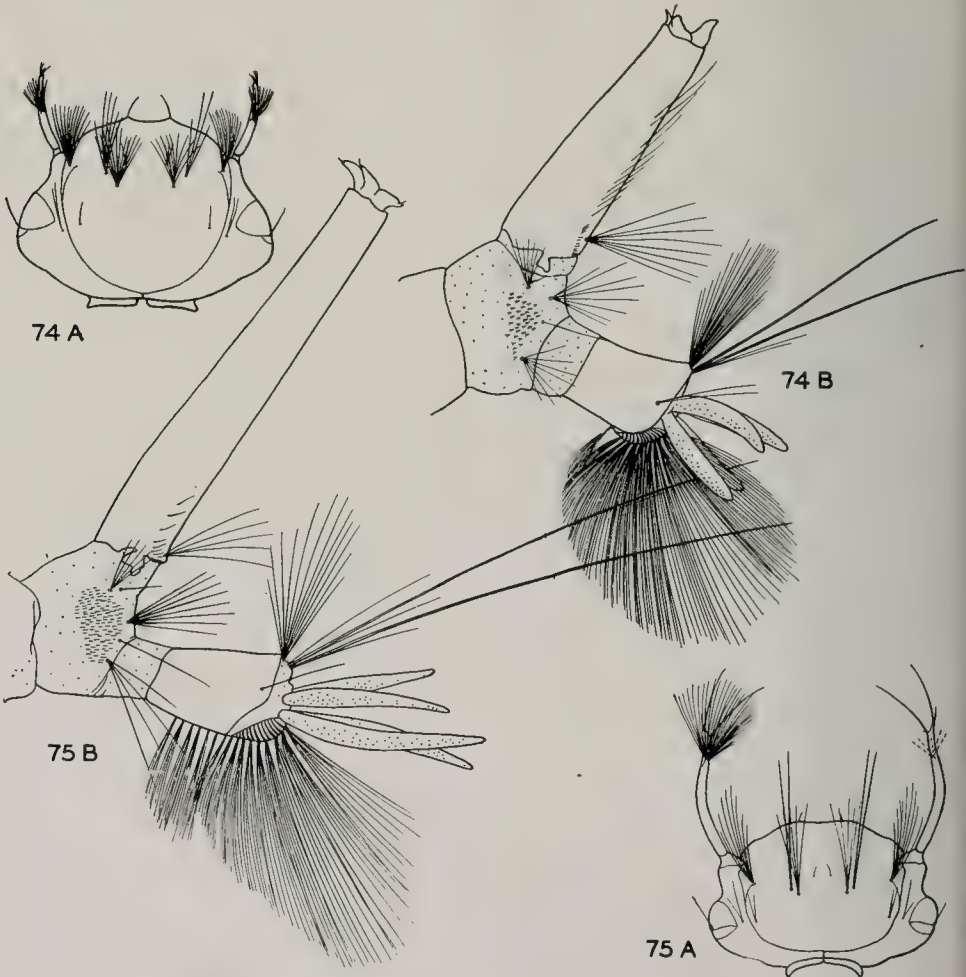
Mesosome wide, bulbous in central portion and only lightly sclerotized, fig. 77.
 2. *morsitans*

1. *Culiseta inornata* (Williston)

LARVA.—Fig. 74. Length 10 mm. Head capsule wider than long, upper and lower head hairs fan shaped, the lower ones usually quadruple, the upper ones with about eight rays; in front of the upper hairs is an accessory pair of tufts, each with about four hairs. Hairs of thorax and abdomen of only medium length. Eighth segment with a triangular comb consisting of about 50 scales. Air tube fairly long, a little over three times

as long as wide; pecten long, the basal 10 to 12 scales sclerotized and dark, the remainder longer, hairlike, and almost colorless; ventral tuft composed of about eight long stout hairs situated near the base of the air tube on the ventral aspect mesad of the pecten. Anal segment completely encircled by sclerotized ring; anal gills long and tapering, longer than segment.

FEMALE.—Wing length 6 mm. Beak, head, mesonotum, and most of legs a mixture of brown and gray scales; pleurae, venter of abdomen, and ventral face of most of legs with gray or cream-colored scales predominating. Dorsum of abdomen with basal bands of cream and tawny scales, apical



Larvae of *Culiseta*

Fig. 74.—*C. inornata*: A, dorsum of head;
 B, apex of abdomen.

Fig. 75.—*C. morsitans*: A, dorsum of head;
 B, apex of abdomen.

portion brown scaled. Wings mostly brown scaled but with a mixture of tawny scales along most of the anterior veins. In some specimens Costa and Radius almost entirely tawny scaled; in these the legs may be predominantly tawny scaled throughout.

MALE.—Form slender compared to that of female. Pattern in general similar to

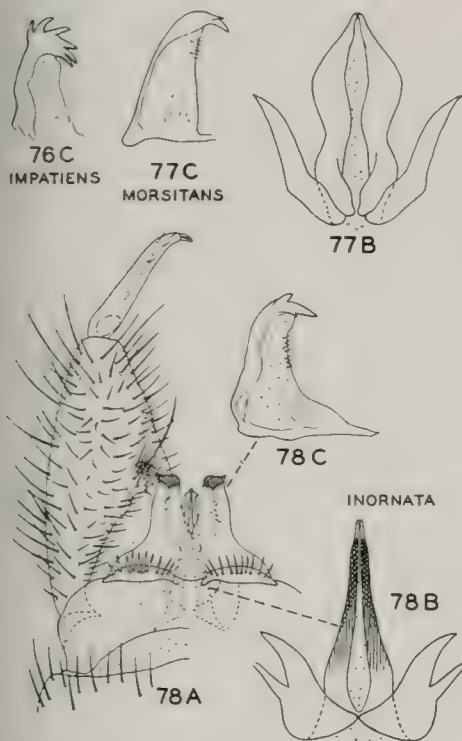
composed of two long sclerotized plates with a slender membranous tip.

One of the common marsh mosquitoes in Illinois, this species is most abundant in the northeastern quarter of the state, where it is found in numbers in almost every marsh. Farther south it occurs in marshes, sink holes, stump holes, and artificial ponds. In Illinois the species apparently has an early spring and late summer generation with a fairly definite period of inactivity during the hottest period of the summer. The two-brooded condition is especially pronounced in southern Illinois, where the first wave of adults comes out in April and early May and the next in September and October. The eggs are laid as rafts on the surface of the water. The adults apparently overwinter and are frequently encountered entering houses, presumably to hibernate, during warm days of November and December. In early spring the overwintered females bite ferociously, but during the summer this species does not seem to constitute much of a pest even in those regions where it is abundant.

Very common throughout almost the entire United States, the species is essentially a winter form in the extreme southeast, according to King, Bradley, & McNeel (1939); in higher elevations of the Rocky Mountains it is primarily a midsummer form. Illinois presents an interesting intermediate between these two extremes.

The species was recorded from the vicinity of Chicago under the name *Culiseta consobrinus* (Robineau-Desvoidy) by Gerhard (1910). Matheson (1930), who recorded it as common and widespread in Illinois, listed several localities. In the same paper he listed a male from Carbondale, Illinois, as *Theobaldia impatiens* (Walker); the cleared genitalia of this specimen show that it is a typical specimen of *Culiseta inornata*.

Illinois Records.—Larvae, collected April 6 to October 22, and adults, collected March 16 to November 16, are from Algonquin, Alton, Amboy, Antioch, Cache, Cahokia (USPHS), Cairo (USPHS), Camp Grant (USPHS), Carbondale, Carterville (USPHS), Cottage Grove, Crab Orchard Lake (USPHS), Dupo, Durand, East Moline (USPHS), East Peoria (USPHS), East St. Louis, Effingham, Eldorado, Elk Grove, Elsah, Farmer City, George Field (USPHS), Gilman, Glencoe, Grand Tower, Granite City (USPHS), Grantsburg, Great Lakes Naval Training Station, Harrisburg, Havana, Hazelcrest, Herod, Herrin, Highland, Hinsdale, Kan-



Figs. 76-78.—Male genitalia of *Culiseta*. A, genital capsule, ventral aspect; B, mesosome, dorsal aspect; C, lobe of tenth sternite, lateral aspect.

that of female but with the cream and tawny scales replaced almost entirely by lemon scales, with little or no banding on the dorsum of the abdomen but with the eighth tergite almost entirely yellow scaled. Palps longer than beak, slender, and without conspicuous brushes, both palps and beak largely yellow scaled, except at tip. Genitalia, fig. 78, with basistyle fairly long, robust, and tapering, with a small meso-basal area bearing a dense patch of setae. Dististyle slender, tipped with a pair of short stout tooth-like setae. Lobes of tenth sternite ending in a few sharp teeth, much fewer than in *impatiens* (Walker), fig. 76. Mesosome

akee, Karnak, Keithsburg, Makanda, Marion (USPHS), McLean, Mazon, Mill Shoals, Mississippi Palisades State Park, Momence, Mount Vernon, Mount Zion, Muncie, Neoga, New Boston, Orland Park, Palatine, Palos Park, Pere Marquette State Park, Ravinia, Rockton, Roxana, St. Jacob, Savanna (USPHS), Scott Field (USPHS), Seneca (USPHS), Springfield (USPHS), Starved Rock State Park, Urbana, Wadsworth, Waltersburg, Ware, Waukegan, White Heath, Willow Springs, Wolf Lake, Woodstock, and Zion.

2. *Culiseta morsitans* (Theobald)

LARVA.—Fig. 75. Length 9 mm. Head very wide, almost rectangular. Upper head hairs usually four or five branched, lower head hairs double and extremely long; between them is a pair of extremely minute hairs. Antennae long and curved with a large tuft near apex. Thorax and abdomen with many very long hairs. Eighth segment with large triangular lateral comb consisting of about a hundred minute scales. Air tube extremely long and slender, nearly seven times as long as wide; pecten consisting of only a few flat teeth on basal fourth; ventral tuft on ventral margin at extreme base. Anal segment entirely enclosed by sclerotized ring, with hairs of ventral brush arising through ring; anal gills slender and pointed, about as long as segment.

FEMALE.—Length of wing 5 mm. Color dark bluish brown, the dorsum of head mostly gray scaled, mesonotum with a few small spots and lines of gray scales. Dorsum of abdomen with a basal gray band on each segment, the apical portion of the segments brown scaled. Legs almost entirely bluish-brown scaled with faint but distinct narrow rings at the base of most of the tarsal segments. Wings entirely blue-brown scaled.

MALE.—Similar in size and color to female. Palps elongate, differing markedly from those of *inornata* in having long ventral brushes at the apex of the second and on all of the third and fourth segments. Genitalia similar in general outline to those of *inornata*, differing markedly in the shape of the mesosome, which is bulbous, sinuate, and not heavily sclerotized, fig. 77.

This is a northern species, which we have taken in Illinois only in a tamarack bog near Antioch. A single larva was taken on the edge of the bog, June 4, 1943, Ross & Sanderson; subsequent collecting during the same year failed to disclose additional

specimens. The next year the bog was visited on April 19, and scattered specimens of the larva were found in the cool, shaded pools around the base of the old tamarack hummocks. Efforts to rear some of these specimens were not successful. The specimens were transported to Urbana, where at the time fairly high temperatures prevailed, and all the larvae died. It is interesting to note that larvae of several species of *Aedes*, brought back at the same time and given the same treatment, emerged without difficulty. On a subsequent visit to the bog on May 19, 1944, larvae were found in the same place and apparently completely full grown. On this occasion, jars in which larvae were placed were wrapped in moist cloths for the trip to Urbana and afterwards were kept in a water bath at a temperature of about 60 degrees F. These larvae matured and transformed slowly but successfully.

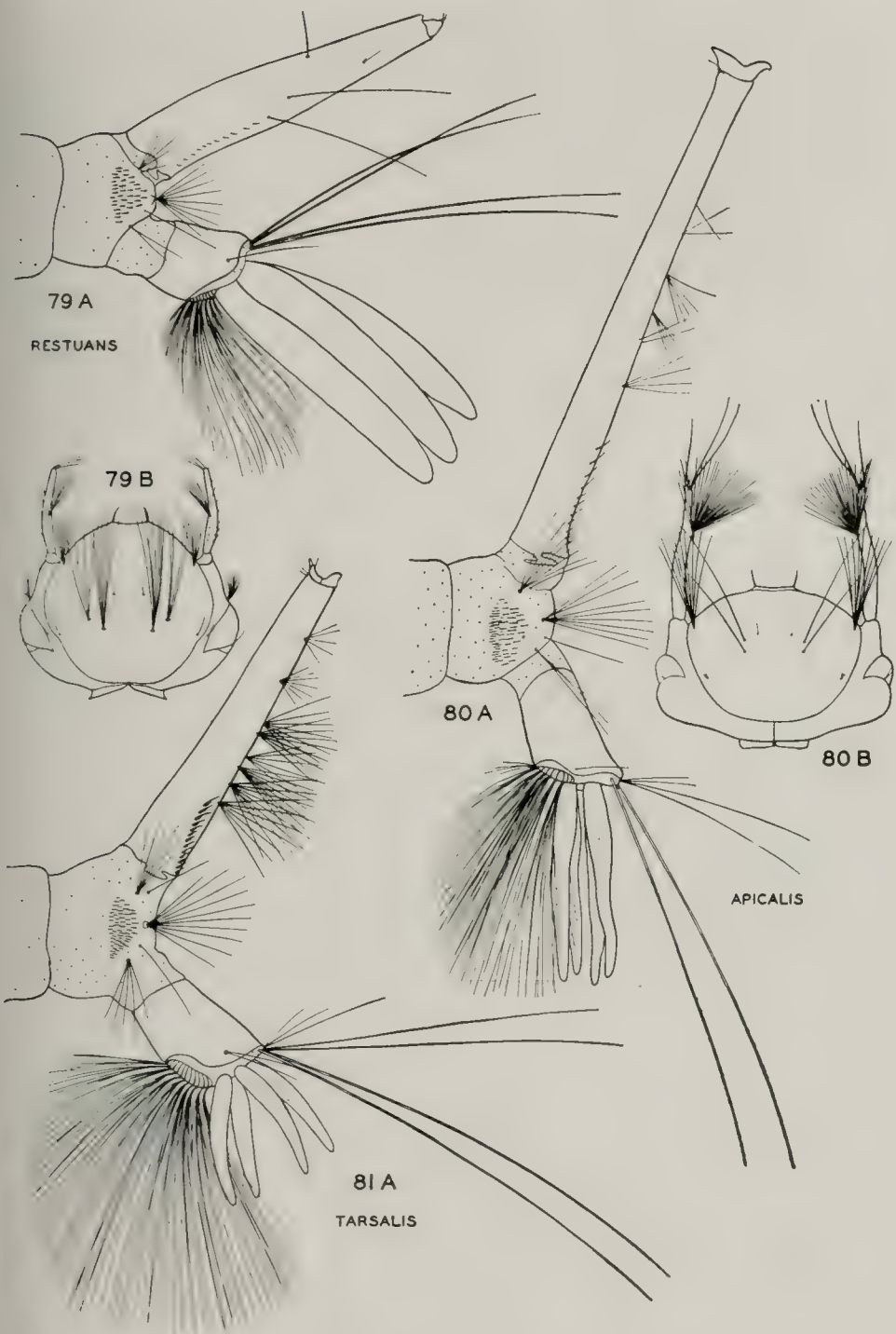
Although no other records for Illinois have been taken, we have in the collection a female from Lake Delavan, Wisconsin, and two females from Minocqua, Wisconsin, which are of this same species; these were incorrectly recorded as *impatiens* (Walker) by Matheson (1930).

8. *CULEX* Linnaeus

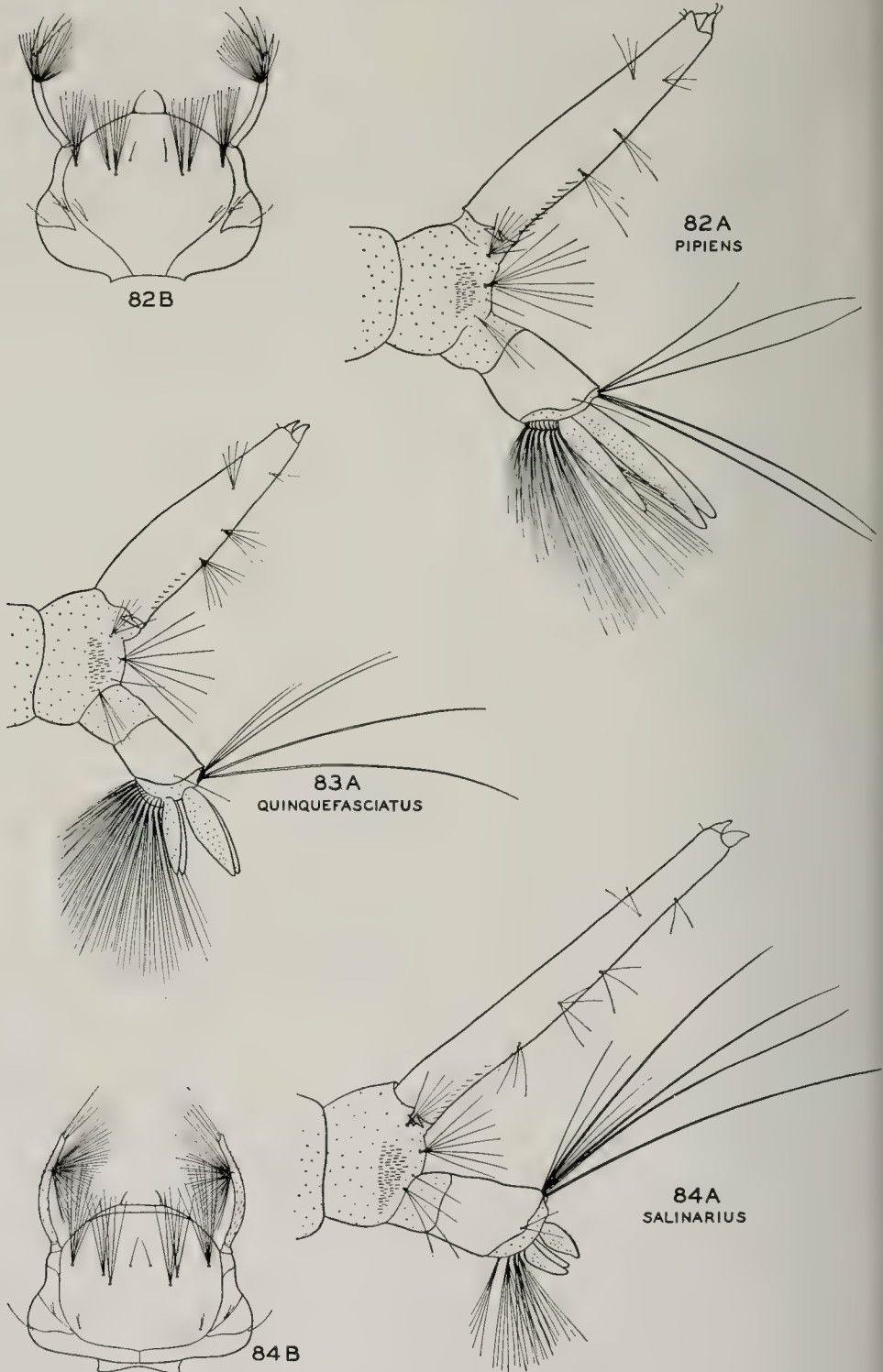
The eight species of this genus that occur in Illinois have a continual series of generations throughout the warmer months of the year. The females lay their eggs in rafts on the surface of the water. The species frequent still or semistagnant water of all types and may be found even in lakes of some size, the larvae breeding in masses of floating or emergent vegetation. Usually the larvae are taken in association with anopheline larvae.

The genus as a whole is tropical or subtropical in distribution. Many North American species occur in the southeastern states, southwest Texas, and southern California. In the Neotropical region, the genus is represented by a very large number of species.

During the period 1941–1945 concerted investigations of the mosquito fauna of the southern areas of the United States led to the discovery of several species of *Culex* hitherto recorded only from the Neotropical region. A digest of these and allied Nearctic species is given in two papers, one by W. W. Wirth (1945) and the other by



Figs. 79-81.—Larvae of *Culex*. A, apex of abdomen, lateral aspect; B, dorsum of head. In figs. 81 and 85, the ventral tufts are shown for both sides of the air tube. In other illustrations, tufts of only one side are shown.



Figs. 82-84.—Larvae of *Culex*. A, apex of abdomen, lateral aspect; B, dorsum of head.

Pratt, Wirth & Denning (1945). These papers supplement the work of Roth (1943) on the Nearctic species of *Culex*.
The genus is divided into many subgenera, three of which are represented in Illinois.

KEY TO SPECIES

LARVAE

- 1. Antennal tuft near middle, fig. 79.....
.....2. *restuans*
- Antennal tuft considerably beyond middle, fig. 80.....2

- Comb scales forming a patch; body only sparsely spiculose; upper head hairs double or triple.....8. *peccator*
- 5. Air tube very long and slender, fig. 84, from six to eight times as long as width at end of pecten; tufts scattered and weak.....5. *salinarius*
- Air tube either not more than five times as long as wide, fig. 82; or with strong, clustered tufts, fig. 81.....6
- 6. Air tube usually six times as long as width at end of pecten, sinuate but of almost uniform thickness throughout, and with

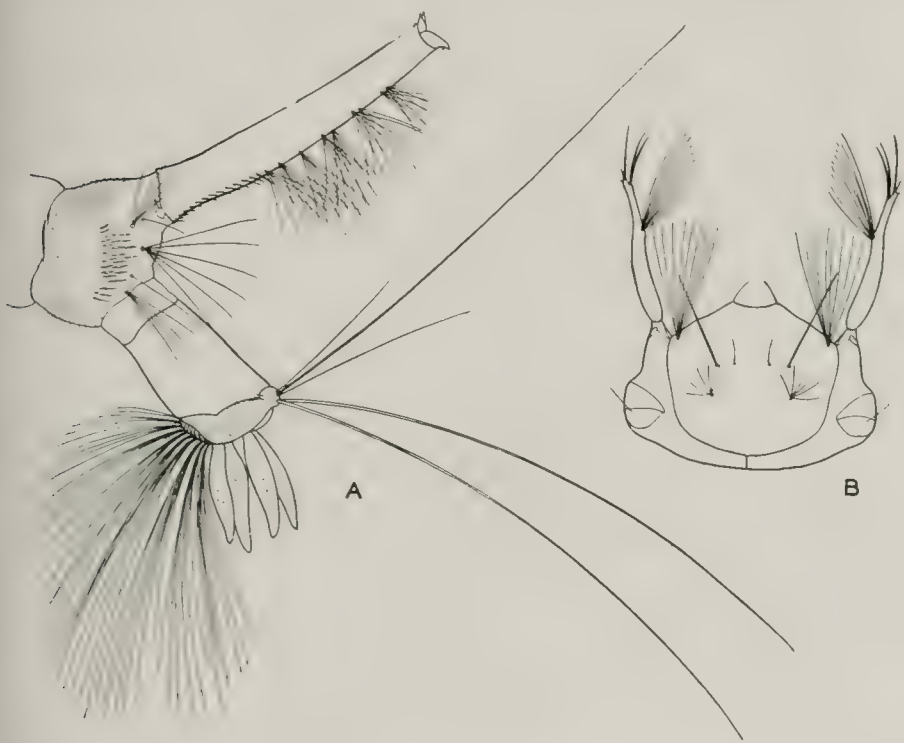


Fig. 85.—*Culex erraticus*, larva. A, apex of abdomen; B, dorsum of head.

- 2. Both pairs of head hairs long and single, an occasional hair double, fig. 80.....
.....1. *apicalis*
- One or both pairs of head hairs either multiple, fig. 82, or very short, fig. 85.....3
- 3. Lower head hairs long and single, upper short and double to multiple, fig. 85....4
- Lower head hairs triple to multiple, similar to upper head hairs, both pairs long, fig. 82.....5
- 4. Comb scales arranged in an irregular single or double row; body densely spiculo-pilose; upper head hairs each with four or more branches; fig. 85....
.....7. *erraticus*

- all tufts near ventral margin, fig. 81.....
.....6. *tarsalis*
- Air tube usually three and one-half to five times as long as width at end of pecten, somewhat vasiform, definitely thickest near end of pecten; penultimate tuft distinctly more dorsal than, and out of line with, the others, fig. 82.....7
- 7. Air tube usually four to five times as long as wide; two basal pairs of hair tufts with a maximum of three or four branches each, fig. 82.....3. *pipiens*
- Air tube usually less than four times as long as wide, two basal pairs of hair tufts with 5 to 10 branches each, fig. 83.....4. *quinquefasciatus*

FEMALES

1. Beak and hind tarsi with white bands; mesonotum with white lines, fig. 86*A*.6. *tarsalis*
Beak and hind tarsi entirely dark; mesonotum with pale dots but without white lines on central portion.2
2. Dorsum of abdomen with apical white bands or apical lateral spots on some of the segments, and without basal bands.1. *apicalis*
Dorsum of abdomen with basal bands but no apical bands.3

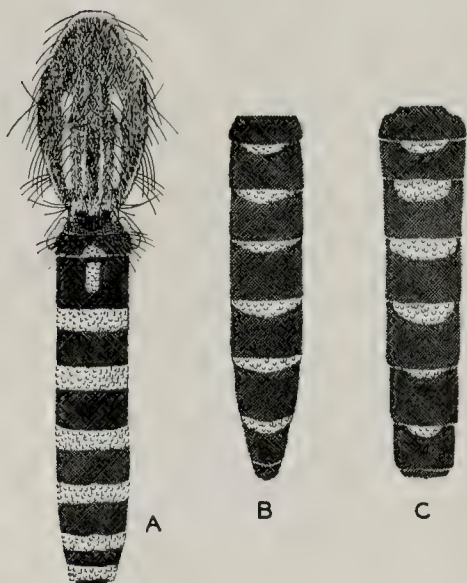


Fig. 86.—Dorsum of *Culex* females. *A*, *C. tarsalis*, thorax and abdomen; *B*, *C. pipiens*, abdomen; *C*, *C. quinquefasciatus*, abdomen.

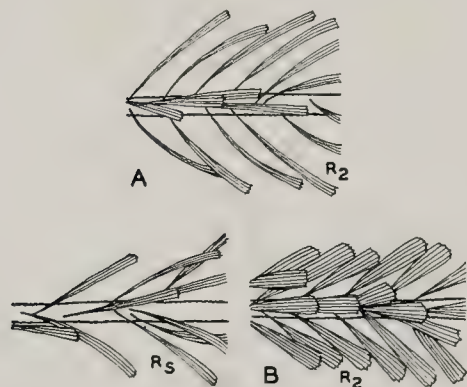
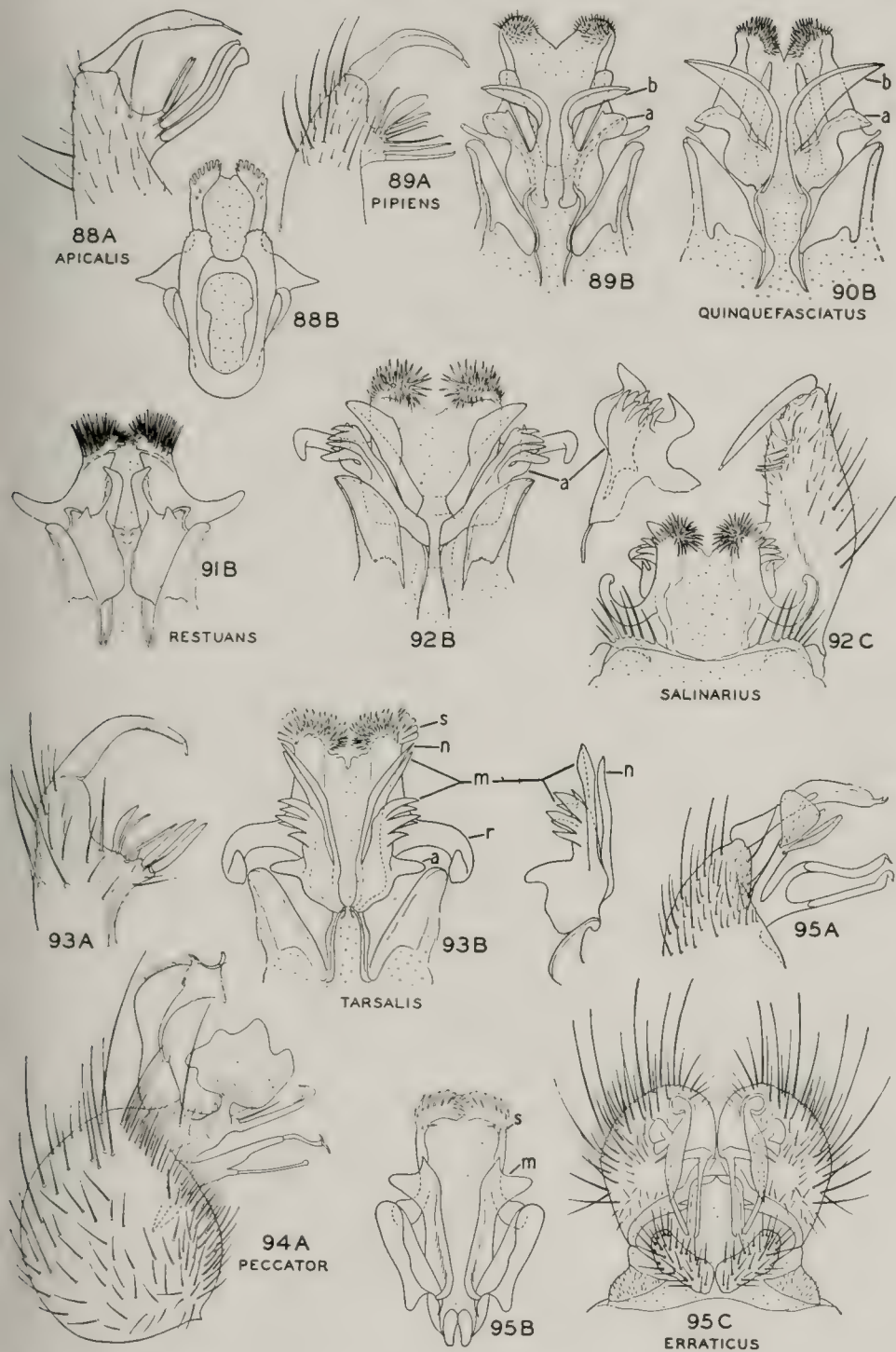


Fig. 87.—*A*, *Culex restuans*, scales on wing vein R_2 ; *B*, *C. erraticus*, scales on wing vein R_s and R_2 .

3. Scales of veins R_2 and R_s very long and slender, fig. 87*A*, similar to scales on stem of R_s (examination of wing mount under a compound microscope is best method for seeing this character)4
Scales of veins R_2 and R_s shorter and wide, fig. 87*B*, contrasting with long, slender scales on stem of R_s 7
4. Abdominal tergites with dingy basal bands of yellowish or brownish scales, the bands usually irregular and narrow5. *salinarius*
Abdominal tergites with bright and conspicuous basal bands of white scales, the central bands wide, fig. 86*B*, *C*5
5. Abdominal dorsal white bands usually deep and crescentic, the bands not extending to edge of dorsum, fig. 86*C*4. *quinquefasciatus*
Abdominal dorsal white bands usually shallower, fig. 86*B*, or with posterior margin straight, extending to edge of dorsum6
6. Mesonotum usually with a pair of central pale spots2. *restuans*
Mesonotum always without any pale spots3. *pipiens*
7. Occiput with a large mesal triangle of narrow scales, the area between this triangle and eyes covered with wide, overlapping scales7. *erraticus*
Occiput entirely covered with wide overlapping scales except occasionally for a narrow mesal line of narrow scales8. *peccator*

MALES

1. Basistyle globular and short; subapical lobe divided into two or three individual long stalks, figs. 94, 952
Basistyle elongate, tapering at apex; subapical lobe only slightly, if at all, subdivided, figs. 88–933
2. Dististyle narrow and only slightly curved; subapical lobe with upper stalk slender, leaflet regular in shape and of moderate size, fig. 957. *erraticus*
Dististyle wide, abruptly angled just beyond middle; subapical lobe with upper stalk stout, leaflet very large and with irregular outline, fig. 948. *peccator*
3. Middle mesosomal plates armed with a cluster of stout sclerotized teeth, figs. 92, 934
Middle mesosomal plates not toothed, in some species not evident, figs. 88–915
4. Inner mesosomal plates with apical half expanded; middle plates with basal projection, *a*, curved back and up under teeth, fig. 92, and without a ventral blade paralleling inner plates5. *salinarius*



Figs. 88-95.—*Culex*, male genitalia. A, claspers, lateral aspect; B, mesosomal structures, dorsal aspect; C, ventral view of capsule. Abbreviations: s, apex of tenth sternite; r, basal arm of tenth sternite; m, middle and, n, inner mesosomal plates; a and b, as in text.

- Inner mesosomal plates narrow and blade-like, apex curved laterad and paralleled by a ventral blade of middle plates; middle plates with basal projection, *a*, projecting only laterad, fig. 93.....6. *tarsalis*
5. Inner mesosomal plates forming a V- or U-shaped structure, middle mesosomal plates also well developed, terminating in a sickle-shaped process, figs. 89, 90.....6
- Inner and middle mesosomal plates not separate from each other, together represented by a single structure, figs. 88, 91.....7
6. Rods of inner mesosomal plates divergent, forming a V-shaped structure, fig. 89.....3. *pipiens*
- Rods of inner mesosomal plates convergent, forming a U-shaped structure, fig. 90.....4. *quinquefasciatus*
7. Inner mesosomal plates with apexes forming a pair of stout rods curved laterad at apex, fig. 91; brush of tenth sternite bushy.....2. *restuans*
- Inner mesosomal plates with apexes forming a pair of round serrate lobes; the entire structure forms a sclerotized oval; brush of tenth sternite comblike, fig. 88.....1. *apicalis*

Subgenus *Neoculex* Dyar

This subgenus is characterized by the apical abdominal bands on the abdomen. The male genitalia have the basistyles elongate, and the middle and inner mesosomal plates are represented by a single structure, fig. 88.

1. *Culex apicalis* Adams

LARVA.—Fig. 80. Head broad and short, antennae long, with long apical setae and a large tuft situated close to the apex. Upper and lower head hairs single and very long. Eighth segment with a triangular comb of about 50 scales. Air tube long and slender, at least 10 times as long as width near the middle of pecten; pecten composed of 10 or more weak scales, beyond which are six or seven ventral tufts.

FEMALE.—Length of wing 2.5 mm. Head and thorax almost entirely light brown. Abdomen dark bluish brown with, usually, a narrow band of white scales along the apical margin of each segment; these bands may be interrupted in the middle of the segments, or completely absent on the basal four or five segments, but are always dis-

tinct on the sixth. Legs with tibiae and tarsi entirely bluish brown, femora chiefly cream color with dark scaling on the upper surface. Wings entirely bluish-brown scaled.

MALE.—Similar to female. Palps long and with an extensive apical brush. Male genitalia as in fig. 88. Basistyle slender, with a distinct subapical lobe bearing a pair of long sinuate narrow processes and a pair of shorter spurs. Tenth sternite with an apical row of truncate comblike setae. Middle and inner mesosomal plates apparently fused to form a heavily sclerotized oval structure beyond which project serrate edges of the ends of the middle plates.

Of the Illinois species of *Culex*, this is the earliest. The larvae are to be found soon after the early spring *Aedes* emerge; in southern Illinois in the latter part of April, in northern Illinois in early June. Apparently a cold water form, the species practically disappears during the hot summer weeks but reappears during the cooler weeks of late summer and early autumn. The larvae show a decided preference for open marshes or moderately shaded pools with clear water. The species is found throughout Illinois and has a wide distribution over most of North America. It is seldom noxious to man.

Illinois Records.—Larvae, collected April 17 to October 17, and adults, collected April 28 to October 6, are from Albion, Algonquin, Alma, Belleville (USPHS), Cache, Cairo (USPHS), Calvin, Camp Ellis (USPHS), Camp Grant (USPHS), Carbondale, Carterville (USPHS), Central City, Chanute Field (USPHS), Clinton, Cottage Grove, Crab Orchard Lake (USPHS), Dixon Springs, Downs, Dupo, Durand, East St. Louis, East Dubuque, Edwardsville, Effingham, Eichorn, Elsah, Epworth, Giant City State Park, Gorham, Gossett, Grafton (USPHS), Grand Tower, Granite City (USPHS), Grantsburg, Great Lakes Naval Training Station, Halfday, Herod, Herrin, Joetta, Johnston City (USPHS), Kappa, Karnak, Keithsburg, Lake Villa, Lake Zurich, La Rue, Lawrenceville (USPHS), Marion, Michael, Mill Shoals, Morris, Mount Carmel, Mount Vernon (USPHS), Mulberry Grove, Muncie, New Boston, New Haven, Oakwood, Olney, Omaha, Palos Park, Pere Marquette State Park, Princeton, Raymond, Rockville, Rockwood, Rosecrans, St. Jacob, St. Joseph, Savanna, Scott Field (USPHS), Seneca (USPHS), Shawneetown, Springfield, Starved Rock State Park, Sugar Grove, Thomson, Urbana, Utica, Vienna, Volo, Wadsworth, Waltersburg, Ware, Wauconda, West Vienna, White Heath, Willow Springs, Yellow Springs, and Zion.

Subgenus *Culex* Linnaeus

In this subgenus the scales on vein R_2 and R_3 are slender and elongate, similar to the scales on the stem of R_2 and R_{2+3} , fig. 87*A*. In the males, the genitalia usually have the basistyle elongate and the middle and inner mesosomal plates differentiated as two pairs of processes.

2. *Culex restuans* Theobald

LARVA.—Fig. 79. Head moderately long. Antennae shorter than head, each antenna having short apical spines and a short tuft situated near middle. Preantennal tuft short and multiple. Upper and lower head hairs multiple and long. Eighth segment with triangular comb of about 30 or 40 scales. Air tube elongate, nearly five times as long as greatest width, slightly enlarged near middle and tapering to apex; pecten composed of 10 or more weak scales, beyond which there are two long setae and a short tuft on each side.

FEMALE.—Length of wing 4 mm. Head and mesonotum bright brown. Mesonotum usually having an indistinct band of cream scales around anterior and lateral portions and around scutellum; usually with a pair of spots of cream color about the middle of the sclerite. Dorsum of abdomen bluish brown, each segment with a basal bright cream band which has a nearly straight posterior margin. Legs with tibiae and tarsi entirely dark, femora cream, frequently with upper and outer areas dark. Wings entirely dark scaled.

MALE.—Similar in size, structure, and general color to female. Palps elongate, with an extensive apical brush. Male genitalia, fig. 91, similar in shape of basistyle, subapical lobe, and dististyle to those of *pipiens*, fig. 89*A*. Tenth sternite with a dense brush of narrow setae and with a moderately developed basal arm. Middle and inner mesosomal plates apparently fused, each side with a broad base, with one or two lateral bumps, and with a long apical process curved sharply laterad at tip.

In Illinois this species is one of the most common mosquitoes in unstocked fish ponds, rain barrels, semidomestic water holes, and pools of many types, especially those with abundant humus. It is distributed over the entire state. It occurs nearly as early in the season as *apicalis* and continues breeding

throughout the summer and into early autumn. Although it has been recorded as a painful biter, some observers believe that it bites little. Judged from our own experience, this species is seldom annoying; certainly it is not such a persistent and vicious biter as *erraticus*. Widespread throughout the eastern and central states from the Atlantic seaboard to the Rocky Mountains, *restuans* extends southward to the Gulf.

Illinois Records.—Larvae, collected April 17 to October 14, and many males and females, collected April 19 to November 23, are from Algonquin, Alton, Anna, Aurora, Belleville (USPHS), Cahokia (USPHS), Cairo (USPHS), Calvin, Camp Ellis (USPHS), Camp Grant (USPHS), Carbondale (USPHS), Carmi, Carterville (USPHS), Chanute Field (USPHS), Charleston, Chester, Clinton, Cottage Grove, Crab Orchard Lake (USPHS), Danville (USPHS), Durand, East Peoria (USPHS), East St. Louis, Elk Grove, Epworth, Forest City, Forest Glen, Fox Lake, Galesburg (USPHS), George Field (USPHS), Gorham, Grafton (USPHS), Grand Tower, Granite City (USPHS), Great Lakes Naval Training Station, Halfday, Havana, Herrin (USPHS), Hoopeston (USPHS), Johnston City (USPHS), Kappa, Karnak, Keithsburg, Lake Villa, La Rue, Lawrenceville (USPHS), Marion (USPHS), Maroa, Milford (USPHS), Mount Vernon (USPHS), Mount Zion, Muncie, New Haven, Oakwood, Olney, Orland Park, Palos Park, Pere Marquette State Park, Pittsburg, Pittsfield, Princeton, Ravinia, Reynoldsville, Ridge Lake, Rising Sun, Riverside, Rockford, Rock Island (USPHS), Roxana, Russellville, Salem, Savanna (USPHS), Scott Field (USPHS), Seneca (USPHS), Shawneetown, Skokie, Springfield (USPHS), Starved Rock State Park, Summerdale, Urbana, Vienna, Wadsworth, Waltersburg, Ware, Waterloo, White Heath, Willow Springs, Winnetka, Wolf Lake, and Zion.

3. *Culex pipiens* Linnaeus

LARVA.—Fig. 82. Head moderately wide, with fairly long apical bristles and a thick tuft situated near apex. Upper and lower head hairs multiple, as long as, or slightly longer than, the preantennal tuft. Eighth segment with triangular comb composed of 30 or 40 small scales. Air tube nearly four and one-half times as long as its width at end of pecten; pecten composed of about 10 weak scales; between the end of the pecten and apex of tube are four tufts on each side, one of them considerably more dorsad than the others; these tufts are long and usually composed of three hairs.

FEMALE.—Length of wing 3.5 mm. Head dark bluish brown with scattered gray scales on dorsum. Mesonotum entirely brown. Dorsum of abdomen bluish brown, each segment with a basal band of white scales; these bands moderately narrow, usually extending the full width of the segment and having the posterior margin irregular or nearly straight across; the bands on segments 3–6 should be used as examples. Legs with tibiae and tarsi black or dark, femora cream with dorsal or outer portions dark.

MALE.—Size, color, and general structure as for female. Palps elongate, with an extensive apical brush. Male genitalia, fig. 89: basistyle slender, its subapical lobe prominent, with a short leaflet and several bristles and spines; dististyle slender and curved. Tenth sternite with an apical brush of fairly short pointed spines, its basal arm slender and short, sometimes poorly developed and inconspicuous. Middle mesosomal plate with two lobes, an irregular sclerotized basal lobe, *a*, and a sickle-shaped apical lobe that has a sclerotized apical edge and a membranous area below this. Inner mesosomal plate composed of a single straight blunt blade on each side, the two forming a V-shaped structure.

Known as the northern house mosquito, this species is common over all of Illinois. The larvae frequent practically all types of domestic and semidomestic pools, such as rain barrels, tar buckets, fish ponds, clogged drains, and containers of various descriptions. The adults are persistent but wary biters, especially annoying at night in gardens or houses. The species occurs throughout the season, from late spring until early autumn. In garden pools it frequently occurs in company with *restuans* and *quinquefasciatus*. It is one of the easier species to control by the use of clean-up measures directed against the semidomestic type of water containers in which this species breeds.

The northern house mosquito is widely distributed over most of the temperate regions of the world having at least moderate rainfall. In the eastern states it extends south of Illinois into the northern portion of the southern states.

Illinois Records.—Larvae, collected from May 3 to September 15, and many males and females, collected from May 6 to November 15, are from Algonquin, Belleville (USPHS), Cahokia (USPHS), Cairo (USPHS), Camp Ellis (USPHS), Carbondale (USPHS), Carmi, Carter-

ville (USPHS), Central City, Chanute Field (USPHS), Charleston, Chicago, Clinton, Cottage Grove, Crab Orchard Lake (USPHS), Danville (USPHS), Decatur (USPHS), Dwight, East St. Louis, Edwardsville, Elsah, Forest Glen, Galesburg (USPHS), George Field (USPHS), Gibson City (USPHS), Grafton (USPHS), Granite City (USPHS), Great Lakes Naval Training Station, Havana, Herrin, Hoopston (USPHS), Johnston City (USPHS), Lawrenceville (USPHS), Marion, Metropolis, Mound City, Mounds, Mount Carmel, Mount Vernon (USPHS), Palos Park, Peoria (USPHS), Ravinia, Raymond, Rockford (USPHS), Rock Island (USPHS), St. Jacob, St. Joseph, Savanna (USPHS), Scott Field (USPHS), Seneca (USPHS), Springfield (USPHS), Urbana, Vienna, Ware, Willow Springs, and Zion.

4. *Culex quinquefasciatus* Say

LARVA.—Fig. 83. Very similar in size, shape, and general structure to larva of *pipiens*. There is often considerable difficulty in separating specimens of the two species. Material of *quinquefasciatus* collected in Illinois is distinguished by the following combination of characters: air tube only about three and one-half times as long as its width at end of pecten; tufts on air tube usually with four or more branches and usually markedly shorter than greatest width of air tube. The gills of both species vary in length.

ADULTS.—Similar in almost all respects to *pipiens* adults. The female usually has definite-shaped basal bands on the abdominal tergites; in *quinquefasciatus* the bands are deeper than in *pipiens* and taper off completely at the edge of the dorsal aspect. Female specimens are encountered, however, in which it is difficult to distinguish between the two species either on this character or any other. The male genitalia are very similar to those of *pipiens* in general conformation. Those of *quinquefasciatus* are distinguished as follows, fig. 90: the distal lobe, *b*, of the middle mesosomal plates is larger and extends farther laterad than in *pipiens*; and the arms of the inner mesosomal plates make a U-shaped structure with converging arms (diverging arms in *pipiens*).

Culex quinquefasciatus, the southern house mosquito, occurs regularly in the southern third of the state but has been taken only sporadically northward. Light trap collections indicate that this species does not appear in numbers until July or August and usually disappears soon after the first

cool weather in September. The larvae frequent the same types of domestic and semidomestic containers as those of *picipiens* and the two species are usually represented in mixed cultures in Illinois. *C. quinquefasciatus* is distributed throughout most of the tropical and subtropical regions of the world. The Illinois records appear to be on the extreme northern edge of its North American range, which extends southward to the Gulf of Mexico.

In much of the literature, this species has been recorded under the name *fatigans* Wiedemann. Edwards (1932) prefers to refer *quinquefasciatus* Say to the list of dubiously known names. Since *quinquefasciatus* has been used consistently as at present, there seems no valid reason for discarding this name in favor of *fatigans*; *quinquefasciatus* was described in 1823, *fatigans* in 1828.

Illinois Records.—Larvae, collected from September 15 to October 1, and adults, collected from June 17 to November 23, are from Belleville (USPHS), Cahokia (USPHS), Cairo (USPHS), Carterville (USPHS), East St. Louis, Edwardsville, Grafton (USPHS), Granite City (USPHS), Herrin (USPHS), Johnston City (USPHS), Marion (USPHS), Mount Vernon (USPHS), Scott Field (USPHS), and Urbana.

5. *Culex salinarius* Coquillett

LARVA.—Fig. 84. Head moderately wide, antennae of moderate length, with long apical bristles and a stout tuft near apex. Upper and lower head hairs long, with at least four branches. Eighth segment with a triangular comb of about 50 small scales. Air tube very long and slender, about eight times as long as greatest width, pecten composed of about 10 weak scales and with several pairs of tufts irregularly placed between end of pecten and apex of tube.

FEMALE.—Length of wing 4 mm. Head and mesonotum bright brown, dorsum of abdomen bluish brown with narrow basal bands yellowish scaled on each segment, the bands frequently indistinct on the basal two or three segments and frequently broken up with brownish scales, giving them a muddy appearance. Legs with tibiae and tarsi entirely dark, femora mostly yellowish with upper and outer surfaces frequently dark. Wings entirely dark-brown scaled.

MALE.—Similar in size, color, and general structure to female. Palps long, having

extensive apical brushes. Genitalia, fig. 92: basistyle long and slender, its subapical lobe with a leaflet and several bristles and spines. Tenth sternite with a dense irregular apical brush and with a long stout basal arm. Middle mesosomal plates with a dorsal cluster of 8 or 10 stout teeth and a sharp upturned stout ventral arm. Inner mesosomal plates divergent, their apices expanded and sinuate.

Although the species occurs generally throughout Illinois, individuals are present usually only in small numbers. Breeding commences fairly early in the season and continues at a fairly uniform rate throughout the summer and into the autumn. The larvae have been taken in a variety of habitats including swampy edges of lakes, oxbow pools, marshes of various types, ponds and cattle tracks, cattail bogs, stump holes, and polluted ditches. The females are said to bite readily, but in Illinois they are not sufficiently abundant to be a nuisance.

The species breeds in the eastern United States westward into the Rocky Mountains, and south to Florida and Texas.

Illinois Records.—Larvae, collected April 16 to October 15, and adults, collected May 5 to November 23, are from Alton, Belleville (USPHS), Cahokia (USPHS), Cairo (USPHS), Camp Ellis (USPHS), Camp Grant (USPHS), Carbondale (USPHS), Carmi, Carterville (USPHS), Chanute Field (USPHS), Cottage Grove, Duplo, East St. Louis, Edwardsville, Equality, Fox Ridge State Park, George Field (USPHS), Gorham, Grand Tower, Grafton (USPHS), Granite City (USPHS), Great Lakes Naval Training Station, Havana, Herrin, Jacksonville, Johnston City (USPHS), Karnak, Lake Glendale, La Ruz, Lawrenceville (USPHS), Marion, Maroa, Mount Vernon (USPHS), Muncie, Olney, Orland Park, Palos Park, Ridge Lake, Rock Island (USPHS), Roxana, St. Charles (USPHS), Savanna, Scott Field (USPHS), Seneca (USPHS), Springfield (USPHS), Urbana, Ware, Willow Springs, and Zion.

6. *Culex tarsalis* Coquillett

LARVA.—Fig. 81. Head moderately broad, proportioned much as in *picipiens*, fig. 82B. Antennae elongate, with long apical bristles and with a tuft near apex. Both upper and lower head hairs multiple and about as long as preantennal hair. Eighth segment with a triangular patch of about 50 small scales. Air tube slender, usually over six times as long as its width at end of pecten; pecten

composed of about 10 weak scales; beyond this are about five pairs of tufts arranged very irregularly but all near ventral margin; the basal three pairs are long and each one has three to six hairs, the apical two short and usually having two to four hairs.

FEMALE.—Length of wing 4.5 mm. Beak and palps dark brown, beak with a white band just beyond middle, palps with extreme apexes tipped with white scales. Dorsum of head with a mixture of brown and gray scales. Mesonotum brown with narrow grayish-white lines as illustrated in fig. 86*A*. Dorsum of abdomen brown with basal patches of white scales. Legs with posterior aspects of femora and tibiae cream, anterior aspects dark brown, each with a central stripe of white scales extending down the middle of this brown area from base to apex, the white line on the anterior legs broken into a series of white bars; tarsi dark bluish brown, all segments of hind tarsi with a white ring at both base and apex of segment, tarsi of front and middle legs with white bands indistinct on, or absent from, the apical two or three segments. Wings dark scaled except for a scattering of white scales on the costal region of each.

MALE.—In size, color, and general structure similar to female. Palps longer than beak, apical two segments with a long brush. Genitalia, fig. 93: basistyle elongate, with a pronounced subapical lobe bearing a small leaflet, a pair of stout spurs and a pair of more slender spines. Dististyle curved and narrow. Tenth sternite with a large apical lobe, the lateral series of teeth truncate and flattened. Middle mesosomal plates with three distinct processes: (1) a large blunt basal tooth, (2) a series of five or six long large sharp teeth, and (3) a curved ventral blade that is closely appressed to the inner mesosomal plate. This last forms a long curved slender blade.

In the plains states this species occurs in very large numbers; in Illinois it has been taken in widely scattered localities over the entire state and only rarely in large numbers. The adults occur chiefly in middle and late summer, with a few persisting into early autumn. The larvae have been found in a wide variety of situations, including hoof prints, pools, stream beds, marshes, and backwaters. A colony at Cahokia, Illinois, occurred in a drainage backwater having a very high pollution by sulfuric acid waste.

The species is said to hibernate as fertilized adult females; the males apparently die at the advent of winter. Breeding begins in early spring and continues until autumn.

The range of the species includes most of the semiarid regions of the west coast and the great plains. Illinois seems to be near the eastern edge of the range. Adults of this species have been found naturally infected with the virus of western encephalomyelitis. The females, which attack men readily, are on the wing chiefly at dusk or after dark. They invade houses often and are fierce and painful biters.

Illinois Records.—Larvae, collected June 11 to October 15, and males and females, collected June 21 to October 28, are from Algonquin, Belleville (USPHS), Cahokia (USPHS), Camp Ellis (USPHS), Carterville (USPHS), Chanut Field (USPHS), Des Plaines, East Peoria (USPHS), East St. Louis, Edwardsville, Fox Lake, Granite City (USPHS), George Field (USPHS), Great Lakes Naval Training Station, Greenville, Havana, Hoopeston (USPHS), Johnston City (USPHS), Marion (USPHS), Milford (USPHS), Savanna (USPHS), Scott Field (USPHS), Seneca (USPHS), Springfield, Urbana, Waterloo, and Zion.

Subgenus *Melanoconion* Theobald

This subgenus is characterized by the wide scales on veins R_2 and R_3 , which are in marked contrast with the long slender scales on R_5 , fig. 87*B*. In the Illinois species, the males have the basistyle almost globular, and the middle and inner mesosomal plates not differentiated from each other.

7. *Culex erraticus* (Dyar & Knab)

LARVA.—Fig. 85. Head moderately wide. Antennae long, with long apical bristles and with a long tuft situated near apex, preantennal tuft long and dense, lower head hairs long, single, and bristle-like. Upper head hairs very short and multiple, with at least four and usually six hairs to each bristle. Abdomen with most of the segments spiculate, having a covering of extremely fine spinules giving it a dense, pilose appearance. Eighth segment with comb consisting of an irregular single or double row of 12 to 15 scales. Air tube only moderately long but narrow, about six times as long as its width at end of pecten; pecten composed of about 12 weak scales; beyond this are four or five

pairs of long multiple tufts situated very close to ventral margin.

FEMALE.—Length of wing 3.5 mm. Head, mesonotum, and dorsum of abdomen almost entirely purplish-brown scaled; abdomen usually with narrow basal bands of cream scales, usually with brown scales intermingled so that the bands are indistinct and muddy. Dorsum of head having a wide triangular mesal area with narrow scales, the area between this and the eye covered with broad overlapping scales; these are in addition to the erect scales that stand up like a comb above this area. Legs dark except for usually creamy portions of femora. Wings entirely dark scaled.

MALE.—Size, color, and general structure as for female. Palps long, with extensive apical brushes. Male genitalia, fig. 95: basistyle short and almost globular; apical lobe produced into three long stout stalks, the two lower ones each bearing a stout flattened process, the upper one bearing a leaflet and three spines; dististyle sinuate, with the end ridged and produced into a pair of minute teeth. Tenth tergite bearing a row of flattened teeth and a stout basal lobe of moderate length. Middle mesosomal plates bladelike and each divided at apex into a short sharp mesal point and a wider blunt lateral triangle. Inner mesosomal plates apparently not differentiated.

Abundant and widespread in southern and central Illinois, this species is a comparative rarity in the northern part of the state. The larvae frequent marshy areas at the edges of lakes, pools, and ponds in which there is abundant emergent vegetation. They are especially numerous in ponds with growth of cattails and water primrose. In addition to ponds, they frequent vegetation-choked shallows along the edges of sluggish streams and ditches. They are usually taken in company with *Anopheles*, and frequently with *Uranotaenia*, also. In Illinois, adult emergence begins in the southern part of the state, usually early in June, and continues until early autumn. The adults attack with persistence and inflict painful bites.

The species is widespread throughout the southern states. Illinois is near the northern edge of its range. It was recorded from Illinois by Matheson (1930) under the name *inhibitor* Dyar & Knab. At that time *erraticus* was generally considered a direct synonym of *inhibitor*. King & Bradley (1937) have shown, however, that *inhibita-*

tor and *erraticus* are distinct species. The name *inhibitor* should be applied to a Santo Domingan species, whereas *erraticus* is the name to be used for this small dark Illinois mosquito.

Illinois Records.—Larvae, collected from June 29 to October 3, and males and females, collected from June 2 to November 4, are from Alma, Belleville (USPHS), Benton, Cahokia (USPHS), Cairo, Carbondale, Cartersville (USPHS), Charleston, Cottage Grove, Coulterville, Crab Orchard Lake (USPHS), Decatur (USPHS), East Hannibal, East Peoria (USPHS), East St. Louis, Edgemoor, Edwardsville, Effingham, Elsau, Fox Ridge State Park, George Field (USPHS), Gibsonsia, Gossett, Grafton (USPHS), Grand Tower, Granite City (USPHS), Grayville, Greenville, Hannibal, Havana, Herod, Herrin, Hull, Johnston City (USPHS), Karbers Ridge, Lake Glendale, Marion, Maroa, Momence, Mount Vernon, Neoga, Oakwood, Olive Branch, Omaha, Peoria (USPHS), Pere Marquette State Park, Pike, Ridge Lake, Rock Island (USPHS), St. Joseph, Salem, Seneca (USPHS), Springfield (USPHS), Ware, West Vienna, and Willow Springs.

8. *Culex peccator* Dyar & Knab

LARVA.—Very similar to larva of *erraticus*, differing as follows: upper head hairs short as in *erraticus* but only double or triple; body only sparsely spiracular; comb with the scales forming a definite patch rather than an irregular line.

ADULTS.—Similar in size, color, and general structure to those of *erraticus*. Both sexes differ in having almost the entire occiput covered with appressed and overlapping scales, at the most with a narrow mesal line of narrow scales. Males differ in characters of the genitalia, fig. 94: the basistyle is nearly globular, as in *erraticus*, the subapical lobe is very definite, the leaflet large, irregular, and expanded, the stalks thicker and definitely proportioned; dististyle very thick, sharply bent at nearly a right angle with a series of concavities and brushlike lines of minute setae.

Like the preceding, this species occurs throughout the southeastern states, where it is usually a rarity. In Illinois, we have taken only a few records of the species and most of these are in the southern fifth of the state. The larvae presumably frequent woodland pools with emergent vegetation. King, Bradley, & McNeel (1939) note that the larvae, when found, are almost always associated with those of *apicalis*.

Illinois Records.—CARBONDALE: June 22–23, 1942, 1 ♂, 2 ♀; October 19, 1943, 1 ♂. CARTERVILLE: Aug. 13, 1942, 1 ♂. GOSSETT: June 3, 1942, Ross & Mohr, 3 larvae. GRANTSBURG: June 10, 1941, Ross & Mohr, 1 larva. LA RUE: Oct. 1, 1942, 1 ♂. OLNEY: June 10, 1941, Ross & Mohr, 1 larva. SCOTT FIELD: Sept. 10, 1942, light trap, 1 ♂.

9. *Aedes* Meigen

To this genus belong nearly half of the Illinois mosquito fauna, with records for 21 species, which include nearly all of the truly nuisance species and both early spring and temporary summer pool species. One or two of the species transmit mammalian diseases.

In all species of the genus, as far as known, the eggs are laid on moist soil or humus, or just above the water line in tree holes or artificial containers. They hatch only after they have been flooded. Some species, in which a desiccation and cold period is necessary for hatching, have only a single generation per year, the adults emerging in early spring. Other species are intermittent breeders and usually have two or three generations per year, depending on the rains.

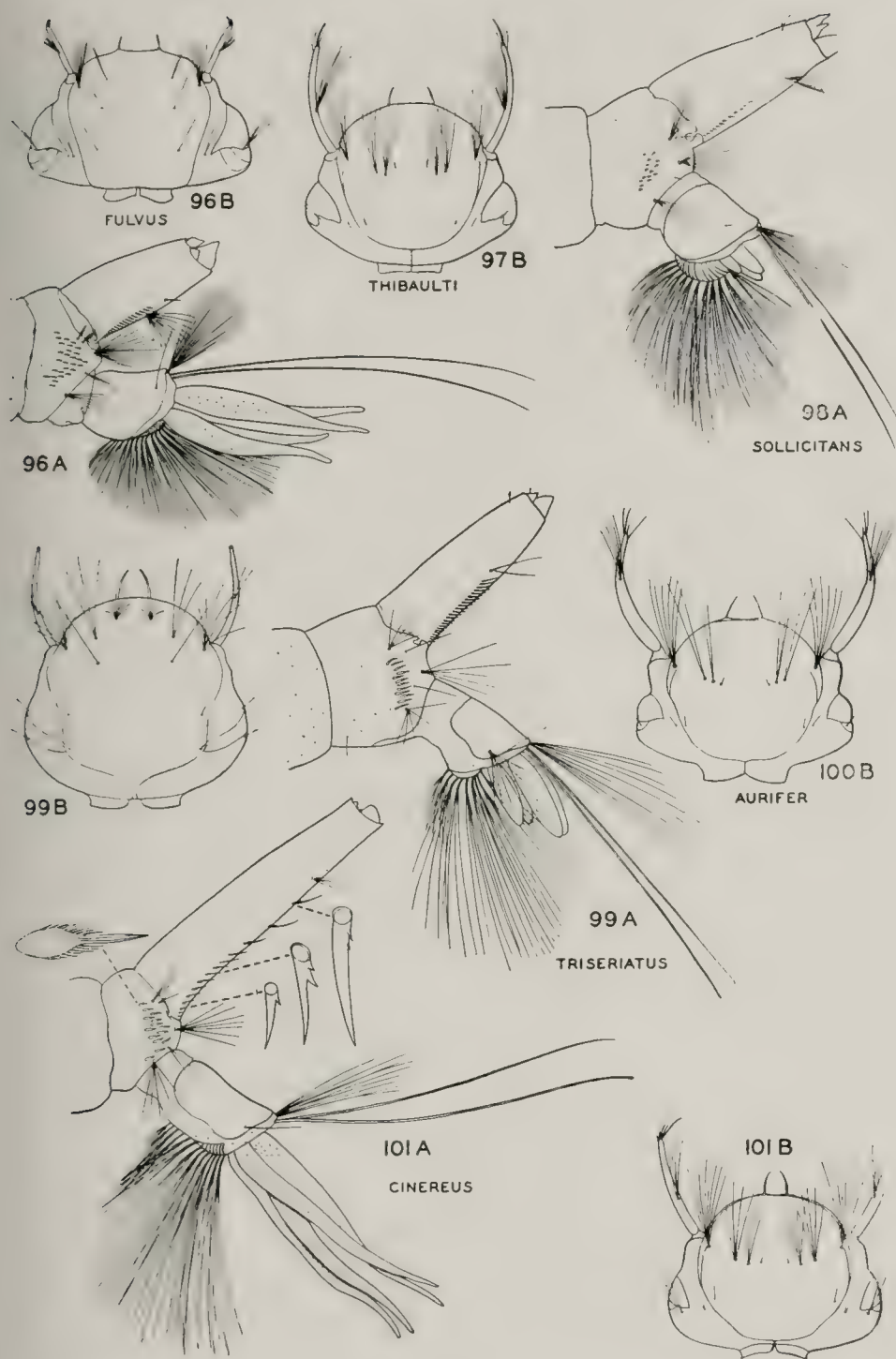
Certain taxonomic difficulties were encountered in studying the genus. The most important resulted in the discovery that in many of the species the head hairs of the larvae were extremely variable, with the result that often in the then existing keys each side of the head of a single individual would key out to a different species. Frequently, on this same basis, specimens of a pure culture would key out to several species. With the Illinois species it was possible to circumvent this difficulty by introducing new key characters especially concerning the relative positions of various stable hairs.

Supplemental material regarding extralimital species may be found in all of the comprehensive treatments of the family listed under the heading "Literature" on page 15.

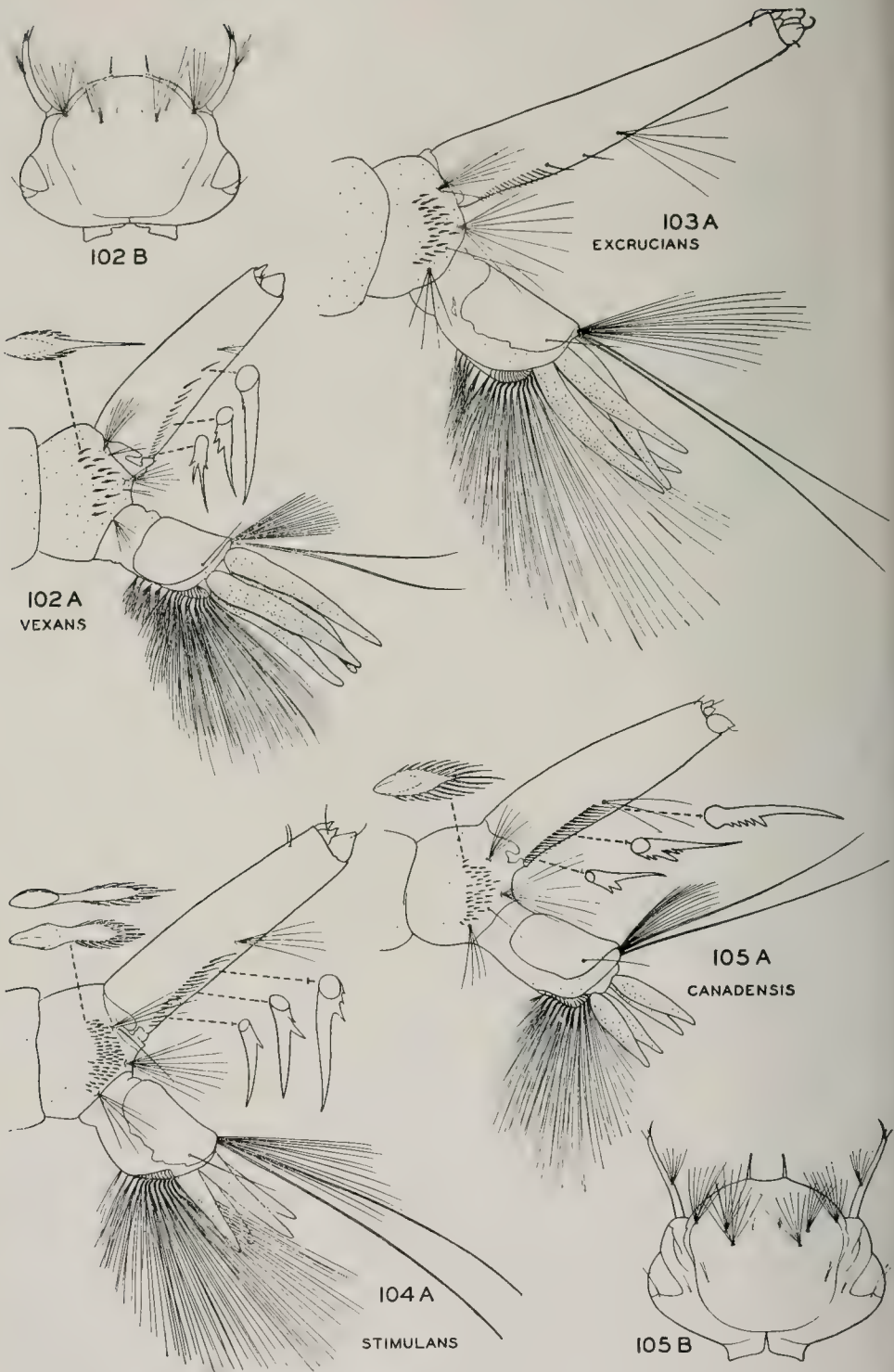
KEY TO SPECIES

LARVAE

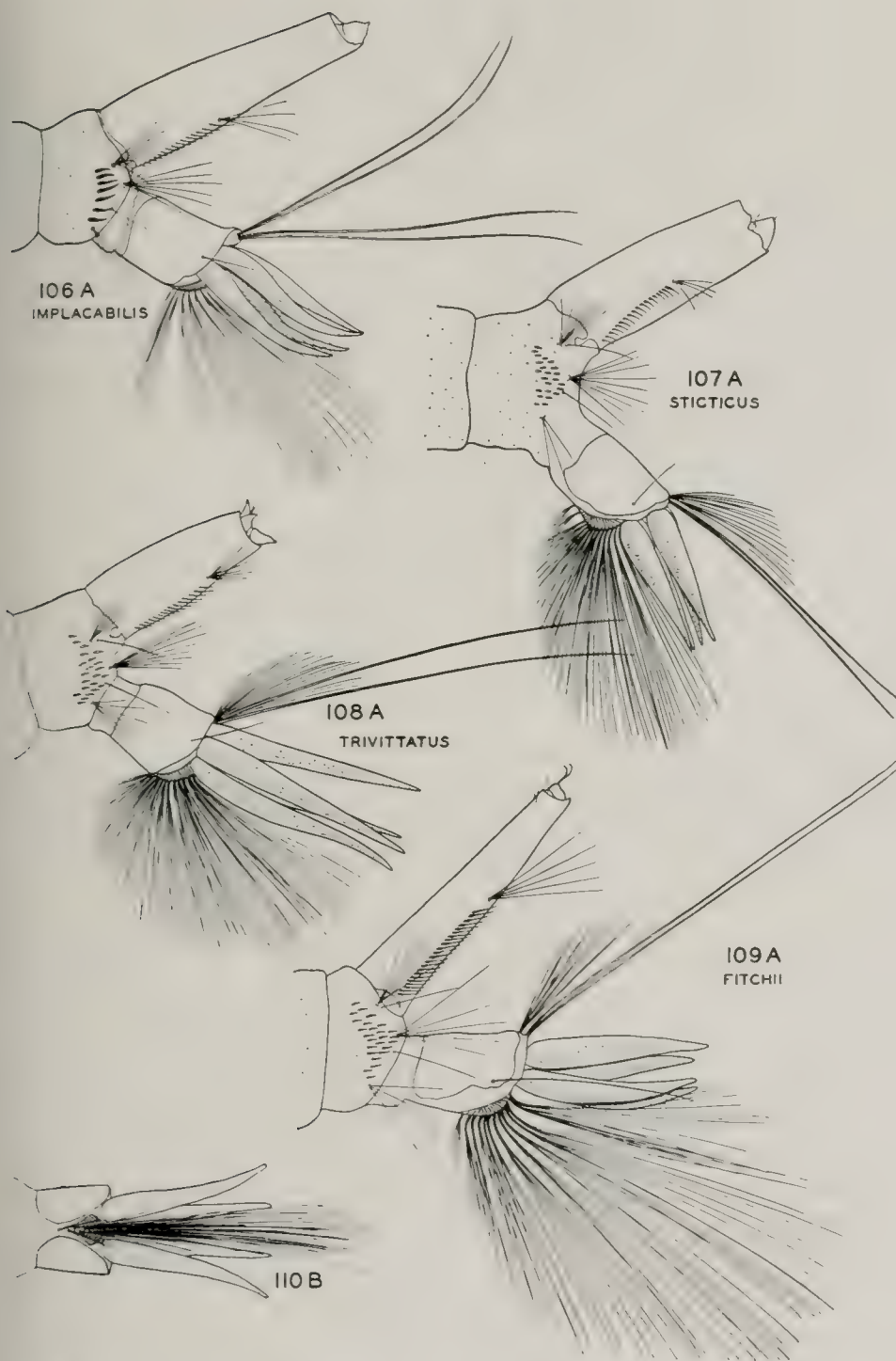
1. Anal segment completely ringed by sclerotized plate, fig. 96.....2
- Anal segment with sclerotized plate not meeting on venter, frequently forming only a dorsal saddle, fig. 99.....9
2. Pecten extending beyond ventral tuft, fig. 96.....21. *fulvus pallens*
- Ventral tuft situated beyond end of pecten, fig. 98.....3
3. Gills budlike, much shorter than anal segment, fig. 98.....4. *sollicitans*
- Gills at least as long as anal segment, fig. 99, frequently very long and pointed at tip, fig. 101.....4
4. Gills extremely long, two or three times length of air tube, and with prominent tracheae, fig. 111; pecten with only a few scales.....20. *dupreei*
- Gills shorter than air tube, without tracheae, fig. 106; pecten with about 15 scales.....5
5. Air tube short, not more than two and one-half times as long as wide, and pecten with several widely detached teeth.....5. *nigromaculis*
- Either air tube over three times as long as wide, or pecten without detached teeth.....6
6. Comb consisting of about 12 scales or less forming a single row, fig. 106.....7
- Comb either consisting of 15 or more scales or forming a double row or triangular patch, fig. 108.....8
7. Comb with 6 evenly spaced teeth; apico-dorsal tuft of anal segment represented by a pair of long, strong setae, as in fig. 106.....22. *implacabilis*
- Comb with about 12 teeth forming an irregular line; apico-dorsal tuft of anal segment many haired, fanlike, fig. 107.....23. *punctor*
8. Air tube with ventral brush two-thirds distance from base to apex, fig. 108.....14. *trivittatus*
- Air tube with ventral brush midway between base and apex.....6. *mitchellae*
9. Head with preantennal hair delicate and single, fig. 112; anal segment with preapical dorsal tuft only three-branched, but as long as apical tuft....2. *aegypti*
- Head with preantennal hair divided into a 4- to 15-branched tuft, fig. 113; anal segment with preapical dorsal tuft 8- to 15-branched, much shorter than apical tuft.....10
10. Pecten with one or more apical teeth spaced fairly wide apart, appearing detached from row, figs. 101–103....11
- Pecten with all teeth close together and forming an even row, figs. 104, 105....16
11. Head with lower head hair considerably laterad of, and only slightly anteriorad of, upper head hair, fig. 100.....12
- Head with lower head hair only slightly laterad of, but considerably anteriorad of, upper head hair, fig. 102.....13
12. Antennae fairly thick at base and long, tuft beyond middle, fig. 100; upper and lower head hairs double, occasionally



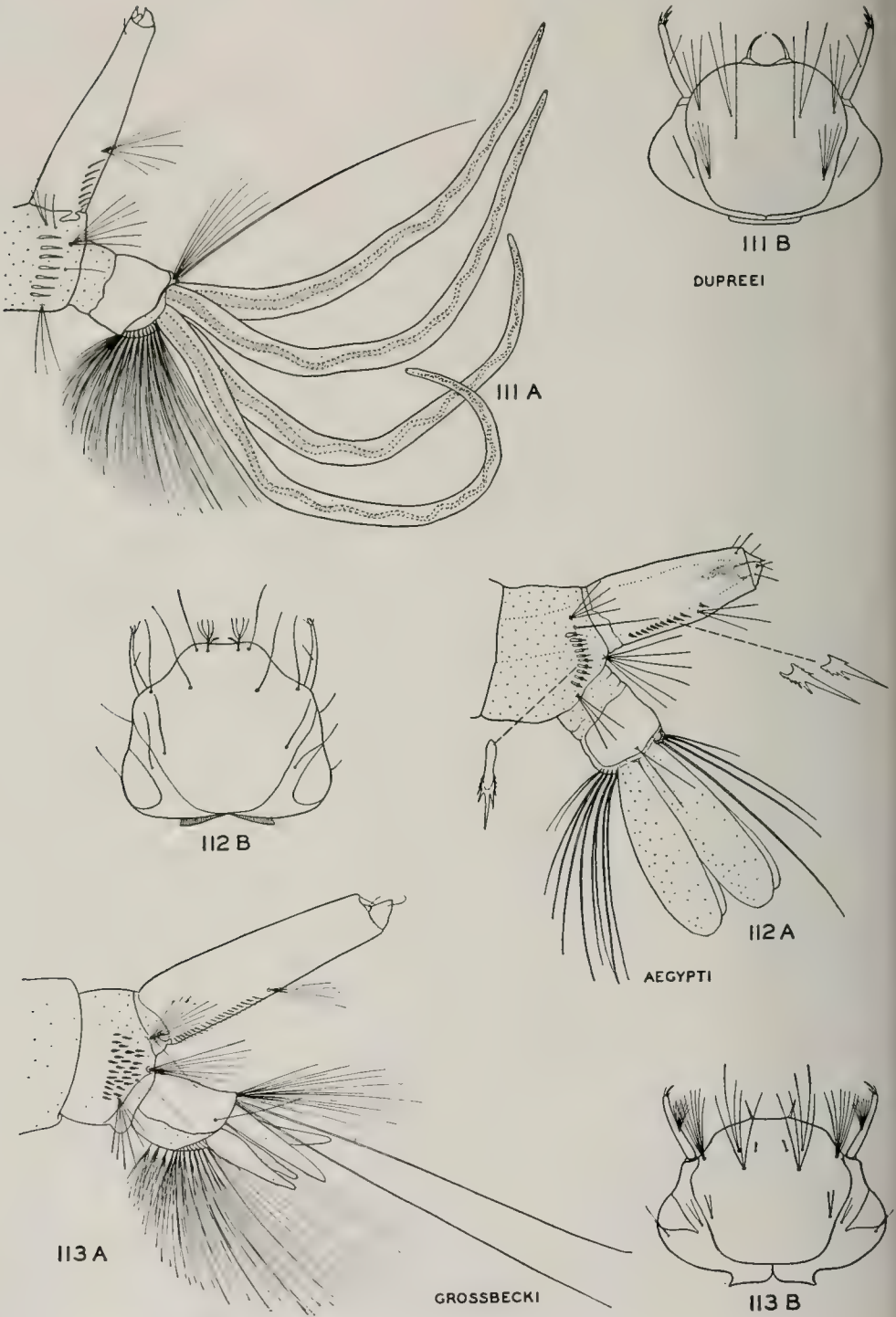
Figs. 96-101.—*Aedes* larvae; A, apex of abdomen, lateral aspect; B, dorsum of head. Inset are details of pecten and comb scales. On these and succeeding larval head drawings of *Aedes*, the mouth brushes are omitted.



Figs. 102-105.—*Aedes* larvae; A, apex of abdomen, lateral aspect; B, dorsum of head. Inset are enlarged drawings of pecten and comb scales.



Figs. 106-110.—*Aedes* larvae, apex of abdomen. All are the lateral aspect except fig. 110B, which is the ventral aspect of *A. spencerii* showing one or two anal hair tufts anterior to the barred area at base of gills.



Figs. 111-113.—*Aedes* larvae; *A*, apex of abdomen, lateral aspect; *B*, dorsum of head. Inset are enlarged drawings of pecten and comb scales. (Fig. 111 redrawn from Dyar.)

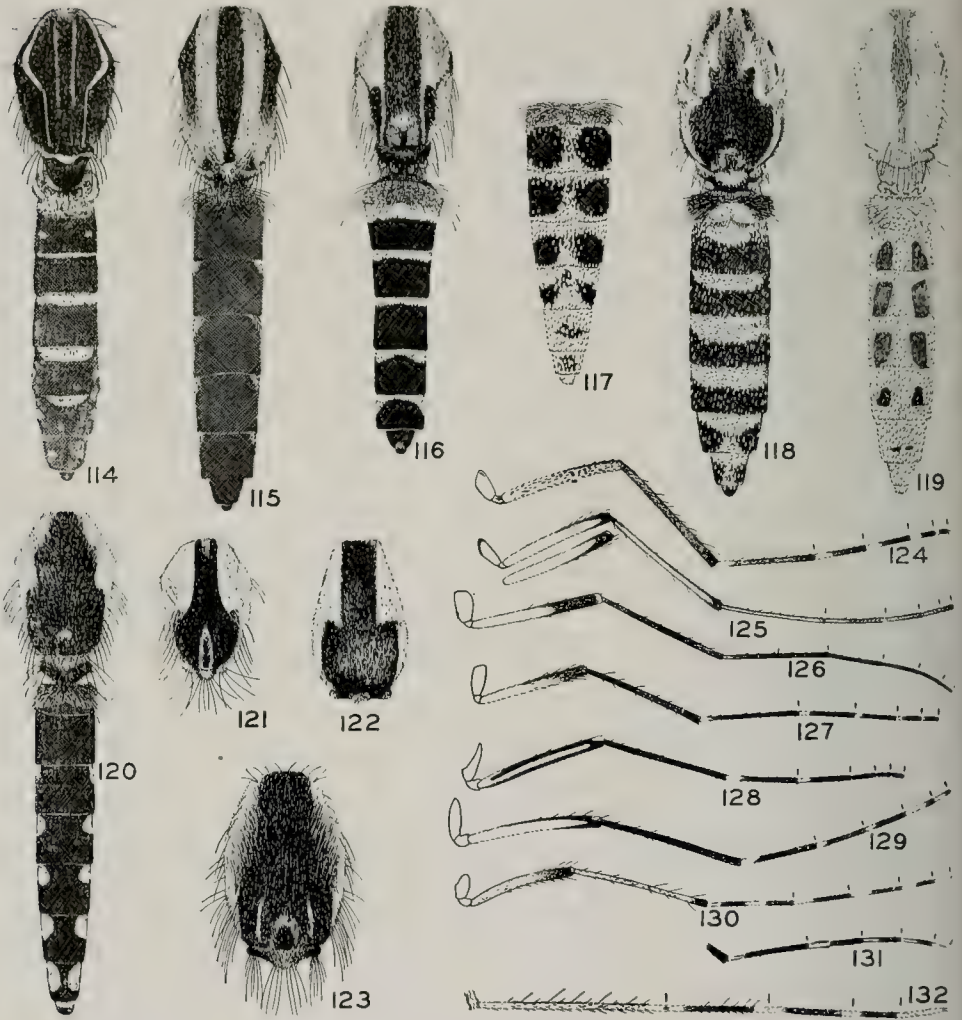
- one of the four triple; clypeal bristles moderately far apart. **15. aurifer**
 Antennae not enlarged at base, tuft below middle, fig. 101; upper and lower head hairs triple to multiple, at least two of the four with four to six branches; clypeal bristles much closer together. **7. cinereus**
13. Air tube five times as long as width at middle of pecten, its ventral tuft very long, fig. 103. **8. excrucians**
 Air tube not more than four times as long as width at middle of pecten, its ventral tuft frequently short, fig. 102. **14**
14. Upper and lower head hairs single; anal segment with only one or two tufts anterior to apico-ventral barred area, fig. 110. **19. spencerii**
 Upper and lower head hairs double to quadruple; anal segment with several tufts anterior to barred area, fig. 102. **15**
15. Lateral comb consisting of more than 20 scales in a triangular patch. **9. flavescens**
 Lateral comb consisting of 10 to 15 scales in an irregular single or double row, fig. 102. **3. vexans**
16. Gills budlike, much shorter than anal segment, as in fig. 98. *A*. **16. dorsalis**
 Gills long, either tapering at apex, fig. 104, or sausage shaped, fig. 99. **17**
17. Lateral comb of segment 8 forming a single row, or an irregular double row of about 10 to 15 large well-spaced teeth, fig. 99. **1. triseriatus**
 Lateral comb forming a somewhat triangular patch containing 20 or more teeth, figs. 104, 109. **18**
18. Both upper and lower head hairs with four or more branches, short, similar in length and appearance to preantennal hair; clypeal hairs only about half as far apart as upper head hairs, fig. 105. **17. canadensis**
 Either upper or lower head hairs with only three branches or less, much longer than preantennal hair, or clypeal hairs about as far apart as upper head hairs, fig. 97. **19**
19. Lower head hairs situated considerably to the side of, and only slightly anterior to, upper head hairs, the upper hairs usually with five branches or more; antennae very long, three-quarters length of head, with antennal tuft very long, fig. 97. **12. thibaulti**
 Lower head hairs almost directly anterior to, and only slightly laterad of, upper head hairs, the latter only rarely with as many as four or five branches; antennae shorter, with a shorter tuft, fig. 113. **20**
20. Air tube five times as long as width at middle of pecten, tapering markedly, so that apex is about half width of base, fig. 109. *A*, its apical spine long and dark. **11. fitchii**
 Air tube at most four times as long as width at middle of pecten, tapering less, so that apex is about three-quarters width at base, its apical spine short and inconspicuous, fig. 107. **21**
21. Sclerotic plate of anal segment only slightly longer than deep, extending more than three-quarters distance down sides of segment, fig. 107; air tube with ventral tuft only about half as long as tuft posterior to comb. **18. sticticus**
 Sclerotic plate of anal segment much longer than deep, extending only one-half or two-thirds distance down sides of segment, fig. 104; air tube with ventral tuft about as long as tuft posterior to comb. **22**
22. Lower head hairs usually single; prothoracic hairs 4 and 7 single; ventral tuft of air tube usually with three or four hairs. **10. stimulans**
 Lower head hairs usually double or triple; prothoracic hairs 4 and 7 usually double; ventral tuft of air tube usually with five to eight hairs. **13. grossbecki**

FEMALES

1. Tarsi with white rings, figs. 127-132. **2**
 Tarsi without white rings, figs. 125, 126. **13**
2. Tarsi with narrow rings at both ends of some segments, fig. 132. **3**
 Tarsi each with a ring at only one end of a segment, fig. 130. **4**
3. Wing scales uniformly dark. **17. canadensis**
 Wing scales mostly white with a small mixture of black scales. **16. dorsalis**
4. Proboscis dark with a definite white band, fig. 35. **5**
 Proboscis nearly uniformly colored. **7**
5. All wing scales dark; hind basitarsus black with a single basal white band, fig. 131. **6. mitchelliae**
 Some wing scales black, some white, giving a spotted appearance; hind basitarsus frequently with a middle yellowish band in addition to basal white band, fig. 130. **6**
6. Abdomen with extensive dorsal areas of cream or tawny scales and small lateral areas of white scales, the two colors definitely contrasting. **4. sollicitans**
 Abdomen with both dorsal and lateral pale scales white. **5. nigromaculis**

7. Mesonotum black with lyre-shaped silver markings, fig. 114.....2. *aegypti*
Mesonotum otherwise, figs. 115-123, never
with extensive silver lines.....8

8. White tarsal rings narrow, fig. 127.....3. *vexans*
White tarsal rings wider, figs. 124, 130
.....9



Color Patterns of Female *Aedes*

Fig. 114.—*A. aegypti*, dorsum of thorax and abdomen.

Fig. 115.—*A. trivittatus*, dorsum of thorax and abdomen.

Fig. 116.—*A. sticticus*, dorsum of thorax and abdomen.

Fig. 117.—*A. spencerii*, dorsum of abdomen.

Fig. 118.—*A. grossbecki*, dorsum of thorax and abdomen.

Fig. 119.—*A. dorsalis*, dorsum of thorax and abdomen.

Fig. 120.—*A. triseriatus*, dorsum of thorax and abdomen. This figure illustrates dark phase of thoracic pattern.

Fig. 121.—*A. triseriatus*, dorsum of thorax of light phase.

Fig. 122.—*A. thibaulti*, dorsum of thorax. (After King, Bradley, & McNeel.)

Fig. 123.—*A. aurifer*, dorsum of thorax.

Fig. 124.—*A. grossbecki*, hind leg.

Fig. 125.—*A. sticticus*, hind leg.

Fig. 126.—*A. triseriatus*, hind leg.

Fig. 127.—*A. vexans*, hind leg.

Fig. 128.—*A. aegypti*, middle leg.

Fig. 129.—*A. aegypti*, hind leg.

Fig. 130.—*A. sollicitans*, hind leg.

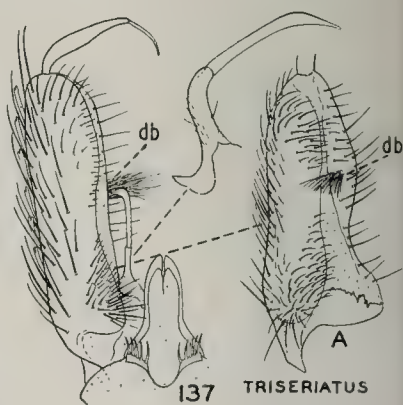
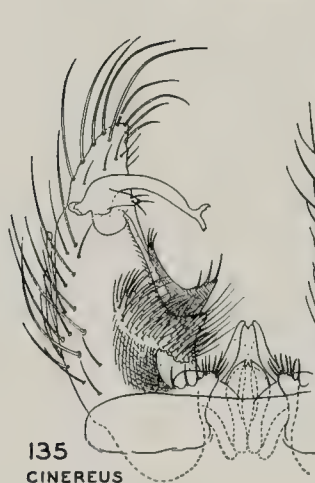
Fig. 131.—*A. mitchellae*, hind tarsus.

Fig. 132.—*A. dorsalis*, hind tibia and tarsus.

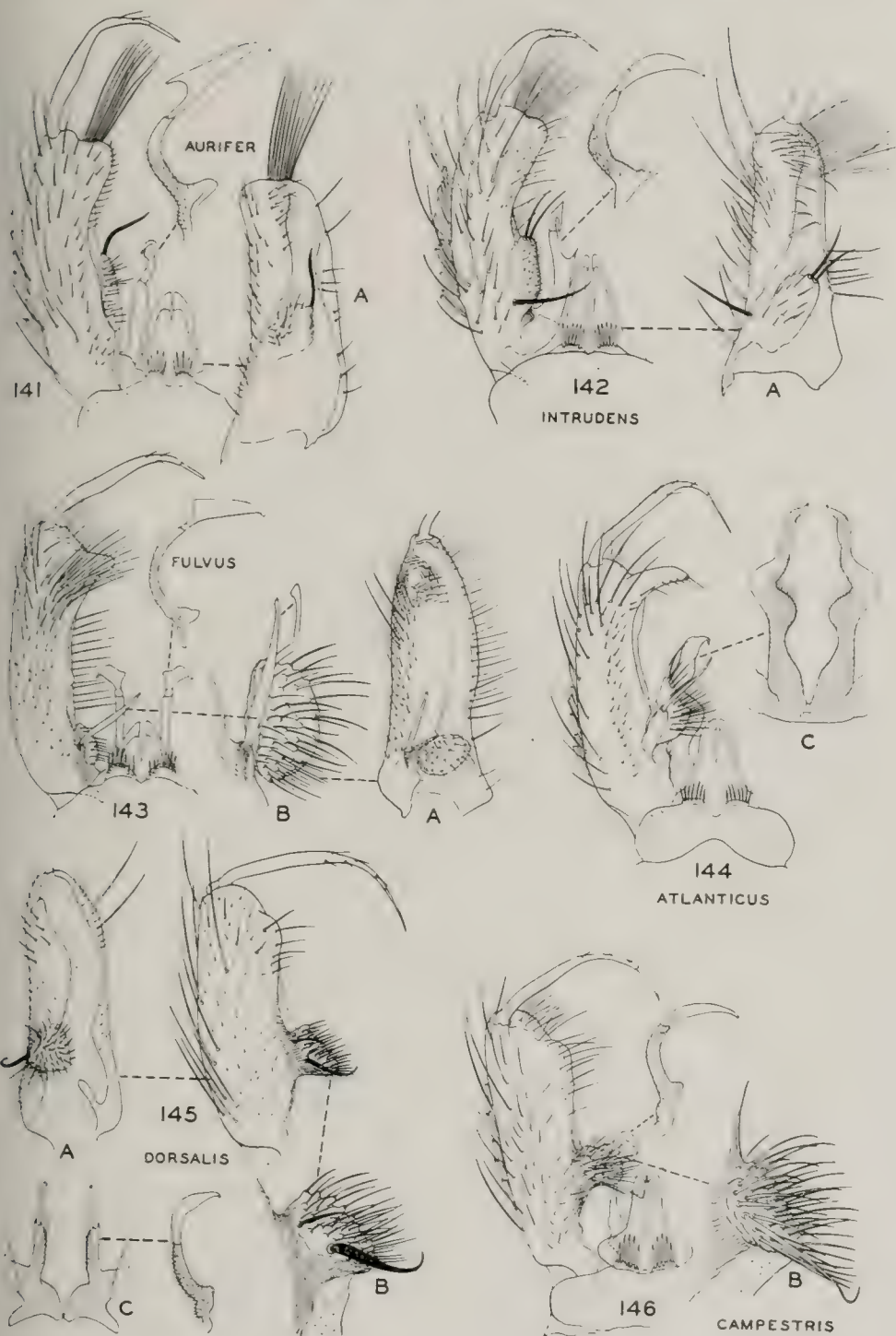
9. All veins of wings with rows of very wide scales, fig. 169; mesonotum as in fig. 118, with a large central black spot enlarged posteriorly.....13. *grossbecki*
Some veins with rows of only long narrow scales, fig. 168; mesonotum marked otherwise.....10
10. Abdomen entirely covered with yellowish scales, without banding; mesonotum entirely yellowish.....9. *flavescens*
Either abdomen with decided banding or mesonotum with a pattern of gray or reddish brown.....11
11. Lower part of mesepimeron with three to five fine long bristles; mesonotum frequently patterned with light gray brown, but occasionally reddish brown.....10. *stimulans*
Lower part of mesepimeron with none to two fine long bristles; mesonotum always predominantly reddish brown.....12
12. Mesonotum with a fairly narrow reddish-brown stripe, flanked with white or cream; one or two lower mesepimeral bristles usually present.....11. *fitchii*
Mesonotum with reddish-brown central area larger and not well defined; no lower mesepimeral bristles present....8. *excrucians*
13. Mesonotum with a definite mesal silvery triangle, flanked with dark areas.....20. *dupreei*
Mesonotum without a mesal silvery triangle, usually with a mesal dark area flanked with light areas, figs. 115, 121.....14
14. Mesonotum with very dark or black mesal area flanked by gray or silvery areas, figs. 115, 121.....15
Mesonotum brown or yellow, often uniform in color, sometimes with mesal area reddish brown and lateral areas light golden brown.....20
15. Central stripe of mesonotum narrow, tapering posteriad, well defined, fig. 115.....14. *trivittatus*
Central stripe either wider posteriad, fig. 121, or parallel sided, fig. 116.....16
16. Central stripe of mesonotum parallel sided, sometimes with a pair of detached short dark stripes along posterior half, fig. 116; abdominal tergites with complete basal or mesal white bands.....17
Central stripe of mesonotum much narrower anteriorly, usually widened posteriorly to almost the full width of the mesonotum, figs. 121, 123, abdominal tergites mostly blue black, with lateral white spots on some segments, but without bands, fig. 120.....18
17. Abdomen with light stripes narrow, regular and basal, widest on basal segment, fig. 116, without mesal or apical stripes.....18. *sticticus*
Abdomen with light stripes basal, apical and mesal, narrowest on basal segments and almost covering the apical segments, fig. 117.....19. *spencerii*
18. Scales of postero-lateral lobes of pronotum white and wide, markedly overlapped to form a solid shingled area, fig. 170, very similar to scales of mesopleurae.....1. *triseriatus*
Scales of postero-lateral lobes of pronotum long and narrow, only half as wide as mesopleural scales, tawny or yellowish in color and not solidly shingled, fig. 171, markedly contrasting with scales of mesopleurae.....19
19. Mesal dark mark of mesonotum with anterior portion narrow, suddenly widened beyond middle to include nearly full width of mesonotum, fig. 122; antero-lateral areas bright grayish white.....12. *thibaulti*
Mesal dark mark of mesonotum with anterior part wider, widening gradually to posterior margin, fig. 123; lateral areas grayish, shading to a golden tint where they merge with mesal dark area....15. *aurifer*
20. Integument and scaling entirely bright golden yellow, except a few black-scaled areas.....21. *fulvus pallens*
Integument dark brown to black, with few or no yellow scales.....21
21. Maxillary palps with apical segments only slightly longer than basal segments; wing at most 4.3 mm. long; abdomen with very narrow cream basal bands on dorsum but with all of ventral part of tergites cream.....7. *cinereus*
Maxillary palps with apical segments twice as long as basal segments; wing over 4.8 mm. long; abdomen either with wide basal bands, or ventral part of tergites with considerable areas of dark scales.....22. *implacabilis*; 23. *punctator*

MALES

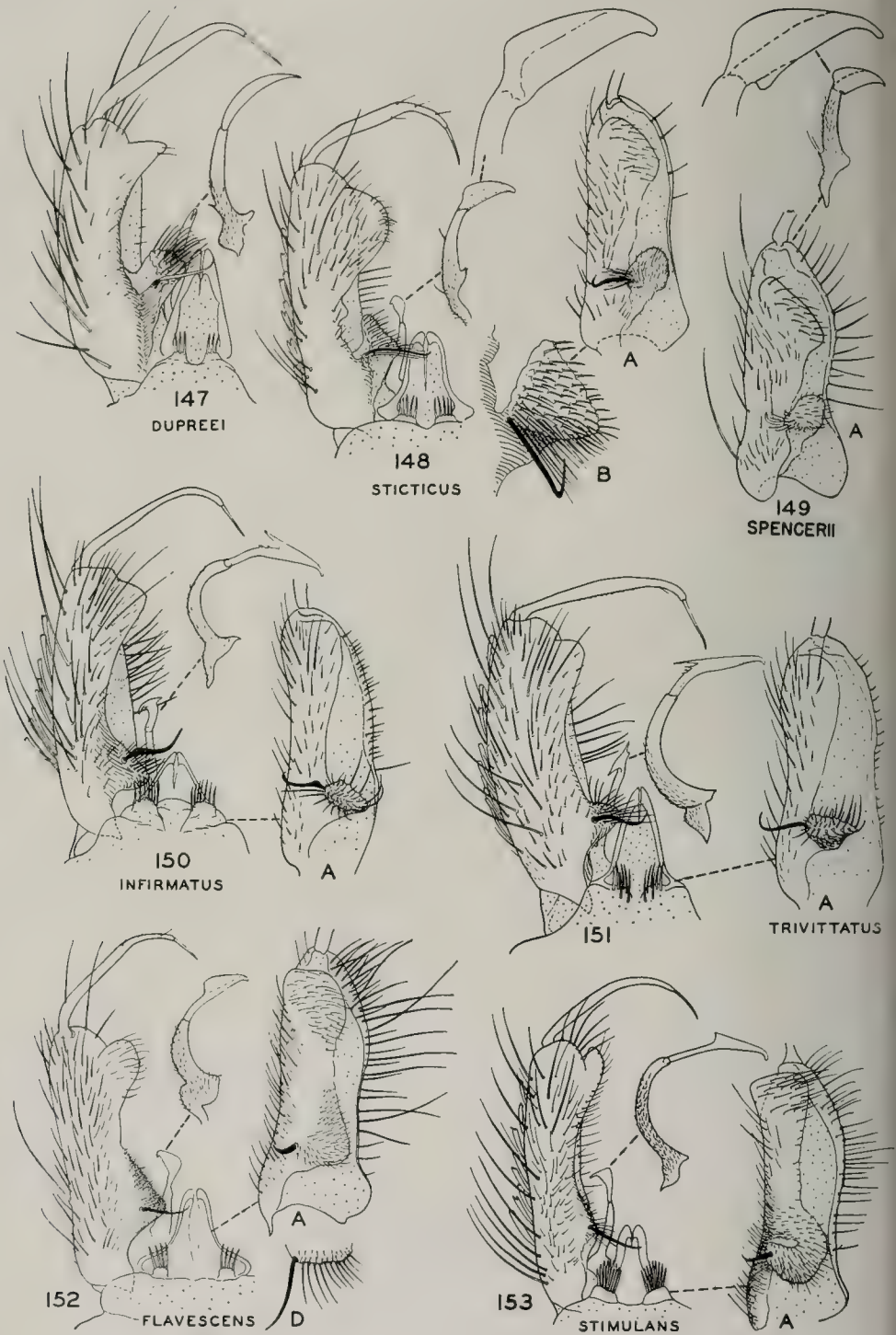
1. Dististyle inserted before apex of basistyle, the portion beyond the dististyle forming an apical cone, fig. 135.....7. *cinereus*
Dististyle articulating as extreme apex of basistyle, fig. 133.....2
2. Dististyle wide near apex, terminating in a sharp projection that is nearly as long as terminal spine; claspettes forming a small, bushy lobe, fig. 133.....3. *vexans*
Dististyle narrow at apex, tipped by terminal spine, fig. 134.....3
3. Claspettes absent, fig. 134.....2. *aegypti*
Claspettes present, figs. 136-158.....4



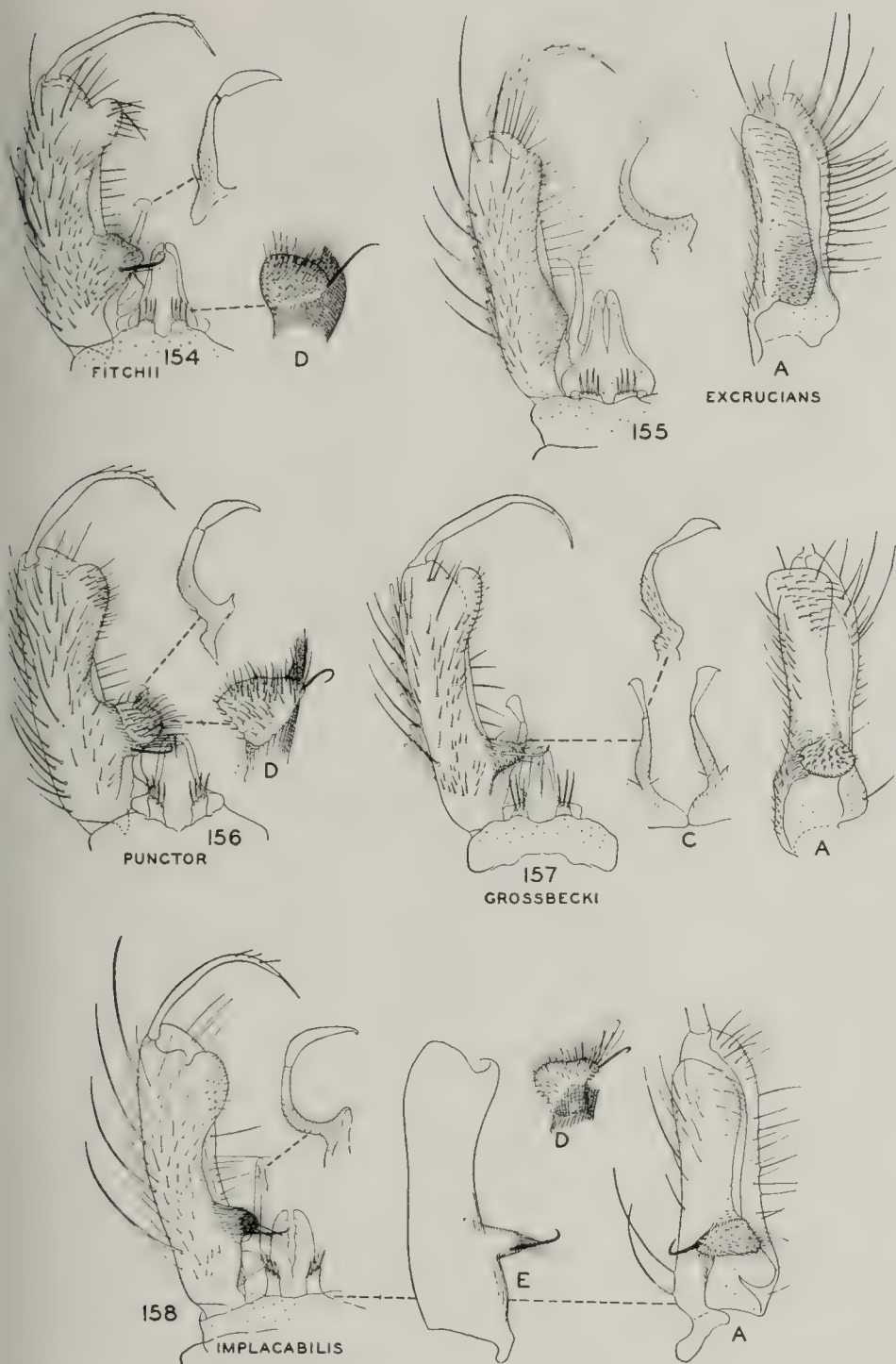
Figs. 133-140.—*Aedes*, male genitalia, ventral aspect; *A*, mesal aspect of bastistyle; *db*, dorsal brush; inset is claspette, lateral aspect. (Figs. 133, 134 after Matheson.)



Figs. 141-146.—*Aedes* male genitalia, ventral aspect. *A*, basistyle, mesal aspect; *B*, enlarged detail of basal lobe, ventral aspect; *C*, claspettes, dorsal aspect; inset is claspette, lateral aspect.



Figs. 147-153.—*Aedes* male genitalia, ventral aspect. A, basistyle, mesal aspect; B, basal lobe, ventral aspect; D, basal lobe, posterior aspect; inset is claspette, lateral aspect and in figs. 148 and 149 a detail of its apex.



Figs. 154-158.—*Aedes* male genitalia, ventral aspect. *A*, basistyle, mesal aspect; *C*, claspette, dorsal aspect; *D*, basal lobe, posterior aspect; *E*, basistyle, ventro-lateral aspect silhouette; inset, claspette, lateral aspect.

4. Basistyle without apical lobe, figs. 136-138 5
 Basistyle with apical lobe definitely developed, figs. 139, 140, or represented by a mass of long setae, figs. 141, 142. 7
5. Basistyle with a thick brush of setae (*db*) on dorsal side, fig. 137; basal lobe with a large area of setae. 1. *triseriatus*
 Basistyle without a brush of setae on dorsal side, but with a definite brush forming the basal lobe, figs. 136, 138. 6
6. Basal lobe a distinct, raised prominence; basistyle considerably widened at basal lobe, fig. 136. 6. *mitchellae*
 Basal lobe represented by only a slightly raised disclike area; basistyle only imperceptibly widened at this point, fig. 138. 5. *nigromaculis*; 4. *sollicitans*
7. Apical process of claspette massive and contorted, fig. 139, the contorted portion thin and pale. 12. *thibaulti*
 Apical process of claspette forming a narrow blade, which may be straight, fig. 140, curved, fig. 143, or barbed, fig. 141 8
8. Basistyle with a dense patch of long setae at apex; basal lobe forming a flat sclerite on mesal face, with a single long dorsal spine, fig. 141. 15. *aurifer*
 Basistyle without a dense apical patch of long spines, but with a well-developed apical lobe; basal lobe otherwise, either projecting, or with a large ventral spine, or without a spine, sometimes with a cluster of long setae. 9
9. Apical lobe with a large dense patch of spatulate setae, fig. 140. 17. *canadensis*
 Apical lobe with setae all narrow and hairlike, figs. 143-158. 10
10. Apical lobe of basistyle very long, a distinct angulation near middle of basistyle, fig. 143; integument of almost entire body yellow. 21. *fulvus pallens*
 Apical lobe either short, fig. 144, or without an extra angulation, fig. 145; integument chiefly dark brown or black. 11
11. Basal lobe with two macrochaetae and many small setae, those near the macrochaetae minute, fig. 145. 16. *dorsalis*
 Basal lobe at most with only one macrochaeta, sometimes with some of the other setae very long, fig. 147. 12
12. Basal lobe triangular and appearing detached, joined to basistyle by only a narrow sclerotized strip, figs. 147-149. 13
 Basal lobe forming a solid part of the basistyle 15
13. Apical lobe small, fig. 147, with a few projecting setae along its mesal margin 20. *dupreei*
 Apical lobe large, fig. 148, with numerous appressed setae along its mesal margin 14
14. Appendage of claspette wide, its lower basal corner produced; mesal aspect of apical lobe long and narrow, fig. 149. 19. *spencerii*
 Appendage of claspette narrower, its lower margin almost confluent in outline with claspette; mesal aspect of apical lobe shorter, decidedly ovate, fig. 148 18. *sticticus*
15. Basal lobe without macrochaetae, having only abundant short setae, fig. 155. 8. *excrucians*
 Basal lobe with at least one conspicuous macrochaeta or a group of long setae, fig. 154. 16
16. Head of claspette produced backward into a sharp basal barb, fig. 151. 14. *trivittatus*
 Head of claspette without a barb, fig. 152 17
17. Basal lobe composed primarily of an area of short setae forming the basal portion of the mesal face of the basistyle, figs. 152, 153 18
 Basal lobe represented by a distinct lobe projecting mesad from the basistyle, figs. 154, 156. 19
18. Area comprising basal lobe long and triangular, its basal spine very large, fig. 152; appendage of claspette fairly short 9. *flavescens*
 Area comprising basal lobe shorter, its lower portion somewhat projecting, its basal spine only moderately large, fig. 153; appendage of claspette very long and slender; a membranous "island" above macrochaeta. 10. *stimulans*
19. Apical lobe short, appendage of claspette elongate with a narrow necklike base, fig. 157. 13. *grossbecki*
 Apical lobe very long, fig. 156, or appendage of claspette without a basal neck, fig. 154 20
20. Basal lobe with membranous, setiferous portion hidden behind sclerotized ventral shoulder, fig. 158, which projects ventro-mesad. 22. *implacabilis*
 Basal lobe with membranous, setiferous portion well exposed from ventral aspect, and without a projecting ventral shoulder, figs. 154, 156. 21
21. Basal lobe with sparse and moderately short setae, without a sclerotized band along the dorsal and mesal periphery; apical lobe with abundant setae on mesal face, fig. 156. 23. *punctor*
 Basal lobe with abundant longer setae which form a thick brush, and with a sclerotized collar around the dorsal and mesal periphery, fig. 154; apical lobe with a few long setae on mesal face. 11. *fitchii*

THE SUBGENERIC UNITS

An investigation of characters of the female genitalia indicates that the subgenera represented in the Illinois *Aedes* fauna are readily segregated on these characters. In those subgenera in which we have more than one species, either no differences were found among the included species (in the case of *Taeniorhynchus*), or the differences observed among the various species were so slight and of such a comparative nature that it was impractical to use them as a basis for identification. These findings follow closely those of Gjullin (1937), who treated western species of the genus.

DIAGNOSIS OF SUBGENERA REPRESENTED
IN ILLINOIS

(BASED ON FEMALE GENITALIA)

1. Postgenital plate elongate, extending three-fourths distance to tip of cerci; eighth segment large and well sclerotized, with short basal membrane, fig. 160. Sole Illinois species, *triseriatus*. . . *Finlaya*
Postgenital plate shorter, its tip not reaching half the distance to tip of cerci, fig. 159. 2
2. Apical margin of eighth sternite with a deep mesal cleft or incision, figs. 159, 163. 3
Apical margin of eighth sternite with only a shallow indentation, fig. 164, or transverse, fig. 167. 4
3. Cerci little longer than ninth tergite; postgenital plate with rounded apex; eighth segment nearly as high as long, fig. 163. Sole Illinois species, *aegypti*.
. *Stegomyia*
Cerci nearly twice as long as ninth tergite; postgenital plate with apex notched; eighth segment nearly twice as long as high, fig. 159. Sole Illinois species, *vexans*. *Aedimorphus*
4. Eighth tergite and sternite almost entirely membranous, with minute sclerotized spots at bases of some setae; apex of eighth sternite forming a moderately sclerotized "flap," which is slightly incised on meson, fig. 164. Only Illinois species, *solicitans* and *mitchellae*.
. *Taeniorhynchus*
Eighth segment moderately and uniformly sclerotized throughout the principal sclerites 5
5. Eighth segment nearly as high as long, the sternite with its apical margin sinuate and not projecting beyond the tergite; cerci short; postgenital plate with a deep cleft, fig. 166. Sole Illinois species, *cinereus*. *Aedes*

Either segment much longer than high, fig. 167, or sternite with nearly straight apical margin, projecting markedly beyond tergite, fig. 162; cerci frequently long, fig. 167, and postgenital plate usually with only a shallow cleft. Contains most of the Illinois species of the genus *Ochlerotatus*

Subgenus *Finlaya* Theobald1. *Aedes triseriatus* (Say)

LARVA.—Fig. 99. Head slightly longer and more rounded than in most other members of the genus; upper head hairs long, slender, and single or double; lower head hairs shorter, double to quadruple, and having between them a pair of distinct plumose tufts. Eighth segment with comb forming a single row varying from a regular one composed of 6 or 8 teeth to a dense, irregular row consisting of 10 to 14 teeth. Air tube about three times as long as wide, both the dorsal and ventral margins curving to form a tapered apex; hair tuft long, single or double, and situated beyond pecten; pecten with 15 to 20 fairly even and quite regularly spaced, closely set teeth. Anal segment with dorsal plate covering only the dorsal half of the segment and bearing a multiple tuft at its postero-ventral corner; anal gills rounded at apex, short, the ventral pair shorter than dorsal pair.

FEMALE.—Length of wing 4 mm. Beak and palps black scaled; back of head silver scaled. Mesonotum with a black central portion and silver lateral areas forming a pattern shown in figs. 120, 121; there is considerable variation in the shape of these markings. Pleural areas with patches of very dense silvery scales. Abdomen with dorsum chiefly blue-black scaled, segments 4-7 with lateral patches of white scales which are smallest on 4, increase posteriorly and usually form a solid white band on 7, venter conspicuously banded with black and white, the white predominating. Legs with tibiae and tarsi blue black, femora with basal half cream, apex blue black, sometimes the anterior face almost entirely blue black. Wings entirely dark scaled.

MALE.—Color identical with that of female. Palps extremely long, projecting beyond beak. Male genitalia, fig. 137, characterized as follows: basistyle without definite apical or basal lobes, the meso-basal portion of the ventral aspect having a large loose brush and dorsal portion having a

conspicuous tuft near middle of mesal edge. Claspettes prominent, the base stout and short, the apical process long and slightly curved at apex.

Breeding primarily in water in tree hole cavities, this species is distributed over the entire state. The adults are sharp biters but apparently do not wander far from the woods in which occur their breeding places. In periods when the rainfall and sap flow refill the tree holes frequently during the summer, this species breeds almost continuously. Development of the larvae is very slow compared to that of species which occur in ground pools. The few observations we have made indicate that the larvae may require nearly a month during the summer to reach maturity. The species hibernates in the egg stage.

Recorded from the Chicago area by Gerhard in 1910, the species was listed as widespread throughout the state by Matheson in 1930.

Illinois Records.—Larvae, collected May 16 to September 16, and adults, collected May 10 to October 22, are from Belleville (USPHS), Cahokia (USPHS), Camp Grant (USPHS), Camp Ellis (USPHS), Chicago, Carterville (USPHS), Crab Orchard Lake (USPHS), Danville, Des Plaines, Dongola, Dubois, East St. Louis, Elsah, Epworth, Glencoe, Gorham, Great Lakes Naval Training Station, Havana, Homer, Johnston City (USPHS), Kappa, La Rue, Lawrenceville (USPHS), Mahomet, Marion (USPHS), Mascoutah, Mount Carmel, Mount Vernon (USPHS), Muncie, Oak Park, Oakwood, Onarga, Pike, Pulaski, Ravinia, Rising Sun, Rockford (USPHS), Roxana, St. Jacob, Scott Field (USPHS), Springfield, Starved Rock State Park, Urbana, Ware, Weldon Springs, and White Heath.

Subgenus *Stegomyia* Theobald

2. *Aedes aegypti* (Linnaeus)

LARVA.—Fig. 112. Head somewhat oval; preantennal hair and upper and lower hairs all very delicate, long, and single; upper hairs almost directly on a line between the two preantennal hairs; lower hairs anterior to upper hairs but situated close to anterior margin of head and with a pair of delicate tufts between them. Eighth segment with comb consisting of a single arcuate row of about 10 toothed scales. Air tube short and relatively stout, about two and one-half times as long as wide and with its ventral margin slightly concave; hair tuft fairly

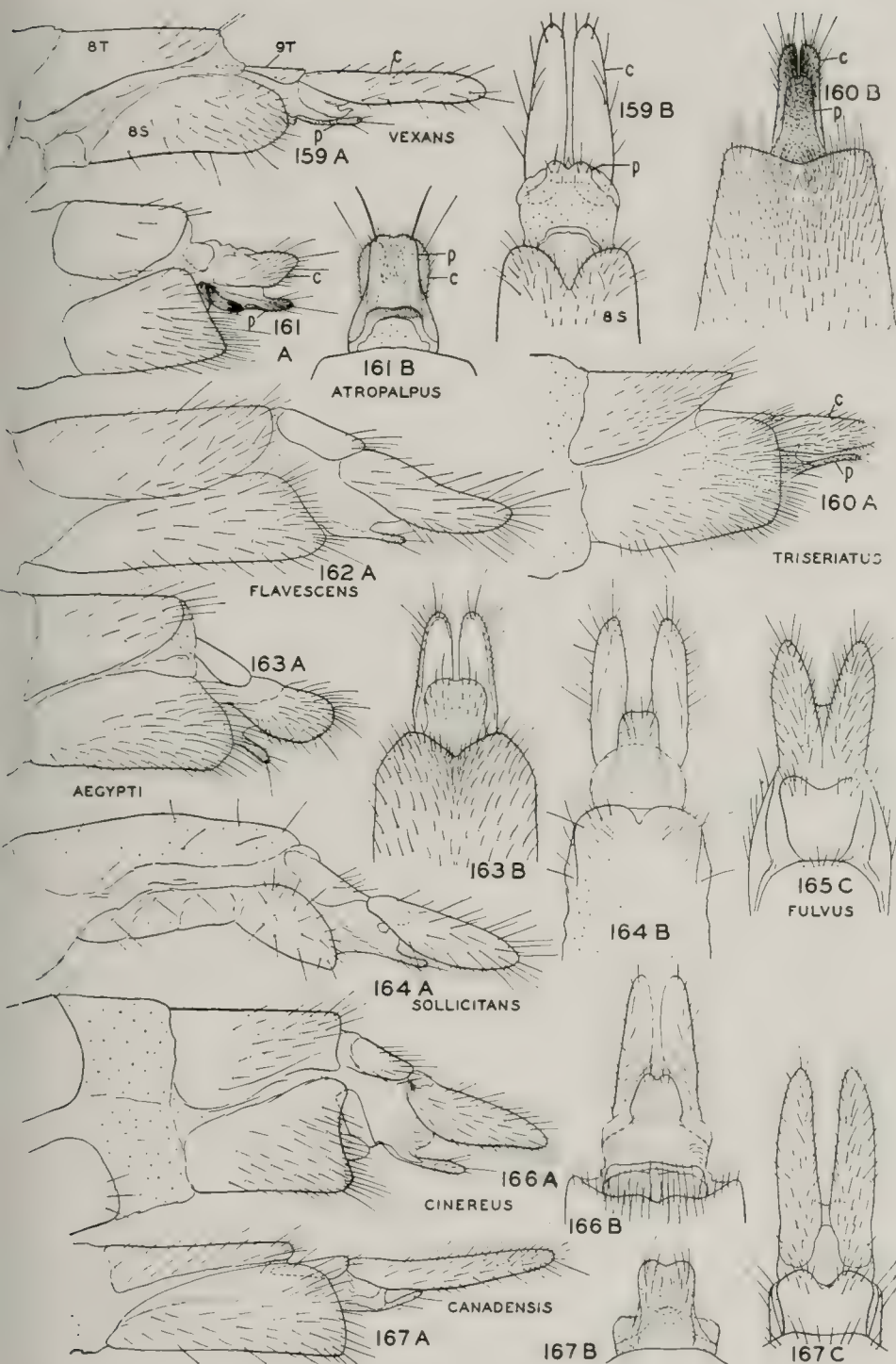
short, usually quadruple, situated just beyond end of pecten; pecten consisting of a close regular row of small teeth. Anal segment with a ventral membranous strip between edges of sclerotized band; each pre-apical dorsal tuft with three to four filaments, apical dorsal tufts each with two, the filaments of both of about equal length; anal gills sausage shaped and about as long as siphon.

FEMALE.—Figs. 114, 128, 129. Length of wing 3.5 mm. Entire body and appendages clothed with very dark brown or black scales having many small and narrow silver spots and stripes, as follows: head with spots at apex of palps, base of antennae and other places; mesonotum with two conspicuous lateral stripes curved so that both form a lyre-shaped pattern, with fainter mesal stripes and three white spots on scutellum; pleurae with several patches of silver scales; abdomen with a narrow white basal band on each segment, with a conspicuous large silver spot on the lateral portion of each tergite, and with the sternites forming a narrow whitish area between these; hind tibiae with a broad white band at the base of each segment, middle and front legs with white bands on only the basal two segments; tibiae black; femora with small white kneecaps and stripes of silver scales along the anterior faces and much of the ventral faces. Wings entirely dark scaled.

MALE.—Similar in size and color to female with the exception of the palps, which are very long, have no apical brushes, and have well-defined conspicuous white bands at the base of each segment. Male genitalia, fig. 134, with very broad robust basistyle, dististyle terminal and simple, and claspettes completely absent.

This species, the widespread yellow-fever mosquito of the South, has been taken at only one or two isolated points in Illinois. In this state it seems to be restricted to isolated small populations that occur as adventives. Apparently none of the introductions has persisted longer than a single summer. The records listed below from Edwardsville appear to be based on the introductions of adults with merchandise; probably no breeding or colonization resulted.

Apparently this mosquito, one of the most important vectors of yellow fever, does not occur in Illinois naturally and is not able to establish itself permanently even when introduced.



Figs. 159-167.—*Aedes* female genitalia. A, lateral aspect; B, ventral aspect; C, dorsal aspect. Abbreviations: *c*, cercus; *p*, postgenital plate; *s*, sternite; *t*, tergite. Fig. 167B shows only the postgenital plate.

Illinois Records.—BELLEVILLE: Aug. 6, 1942, C. J. Rohde, 1 ♀ (USPHS); Aug. 26, 1942, chicken coop, 1 ♀ (USPHS). EDWARDSVILLE: Sept. 24, 1943, biting in shop, Ross & Sanderson, 4 ♀; Oct., 1943, Ross & Sanderson, 1 ♂, 6 ♀. WATERLOO: Sept. 14, 1942, J. Williams, 1 ♀ (USPHS).

Subgenus *Aedimorphus* Theobald

3. *Aedes vexans* (Meigen)

LARVA.—Fig. 102. Head with upper hairs sometimes triple, sometimes quadruple, lower hairs double or triple, both of moderate length and without tufts between them. Eighth segment with comb variable, ranging from 6 to 12 teeth arranged in a scattered single row or an irregular double row. Air tube three and one-half to four times as long as wide; hair tuft short, usually quadruple, situated well beyond the pecten; pecten with 17 to 25 teeth, the basal teeth small, one to three apical teeth very large, widely separated from the remainder of the pecten, and, if more than one, from each other. Anal segment with sclerotized ring not complete ventrally; anal gills longer than ring, tapering gradually and pointed at apex, sometimes nearly as long as the air tube.

FEMALE.—Length of wing 4.5 mm. Head variegated with gray and brown, palps mostly brown-and-black scaled, with a small patch of white scales at apex. Mesonotum almost uniformly dark-brown scaled except for irregular posterior and lateral patches of gray scales. Abdomen with dorsum conspicuously banded, each segment with a basal white band and an apical bluish-brown band; the apical tergites frequently have an additional narrow white band of scales and the basal white bands are usually very narrow on the meson; venter of abdomen almost entirely white scaled. Legs, fig. 127, with tarsi black, each segment with a basal white band; these white bands may be extremely narrow on all the segments but are always conspicuous on the posterior tarsal segments and may occupy a quarter of the length of each segment. Wings entirely bluish-brown scaled.

MALE.—In size and color similar to female, differing chiefly in the long palps, which have a white-scaled band at the base of each segment. Genitalia, fig. 133, readily distinguished by the following characteristics: basistyle with only an inconspicuous

basal swelling; dististyle with the apical spine prominent and arising a short distance from the apex, this spine and the pointed apex usually appearing as a fork; claspettes short and surmounted by a tuft of short setae.

The commonest mosquito in Illinois in point of numbers throughout the warmer months of the year, *Aedes vexans* has a range that blankets the entire state. It is a vicious biter and breeds in a wide variety of temporary pond situations. Especially abundant after the summer rains, when it emerges in clouds from many types of rain pools and the flooded edges of marshes, *vexans* is the greatest mosquito nuisance in the state. To date the species is not known to transmit human diseases.

There is a great deal of literature on this mosquito. Formerly it was recorded as *sylvestris* Theobald. Holarctic in distribution, it does not extend in numbers into the extreme southern United States but is abundant at least as far south as southern Illinois.

The species may have several generations each year. The first brood of adults typically emerges in early spring, a week or so after emergence of *canadensis* and *sticticus*.

Illinois Records.—Larvae, collected April 3 to September 9, and many males and females, collected April 5 to October 26, are from Algonquin, Allendale, Altamont, Amboy, Antioch, Arcola, Baker, Beach, Belleville (USPHS), Benton, Bensenville, Billett, Bishop, Bourbonnais, Cache, Cahokia (USPHS), Cairo, Calvin, Camp Ellis (USPHS), Camp Grant (USPHS), Carbonale (USPHS), Carterville (USPHS), Cary, Casey, Cave-in-Rock, Central City, Champaign, Channel Lake, Chanute Field (USPHS), Charleston, Chebanse, Chemung, Chester, Chicago, Cordova, Danville, Darwin, Del Rio, Des Plaines, Downs, Duncans Mills, Dupo, East Dubuque, East Moline (USPHS), East Peoria (USPHS), East St. Louis, Edwardsville, Effingham, Eichorn, Eldorado, Elgin, Elizabethtown, Elsah, Epworth, Farmer City, Fort Massac State Park, Fox Lake, Fox Ridge State Park, Frankfort, Franklinville, Fulton, George Field (USPHS), Gilman, Glencoe, Golconda, Gorham, Gossett, Grafton (USPHS), Grand Tower, Granite City (USPHS), Grantsburg, Grass Lake, Grayslake, Grayville, Great Lakes Naval Training Station, Halfday, Hamel, Hardin, Harding, Havana, Hazel Crest, Hebron, Herod, Herrin, Homer, Horse Shoe Lake, Jerseyville, Joetta, Johnston City (USPHS), Joliet, Kampsville, Kankakee, Kappa, Karnak, Kcensburg, Keithsburg, La Grange, Lake Bluff, Lake Fork, Lake Glendale, Lake Villa,

La Rue, La Salle, Lawrenceville (USPHS), Libertyville, Lincoln, Mahomet, Makanda, Marissa, Mascoutah, Mattoon, Mazon, McHenry, Metropolis, Mill Shoals, Mississippi Palisades State Park, Momence, Monticello, Morris, Mount Carmel, Mount Vernon, Mount Zion, Muncie, Neoga, New Boston, New Haven, New Holland, Northmoor, Oak Park, Oakwood, Oilfield, Olney, Oregon, Orland Park, Oswego, Palatine, Palestine, Palos Park, Patton, Pecatonica, Pembroke, Peoria (USPHS), Pere Marquette State Park, Pike, Pingree Grove, Pittsfield, Princeton, Quincy, Ravinia, Reynoldsville, Richmond, Ridge Lake, Rising Sun, River Forest, Robinson, Rockford, Rock Island (USPHS), Rockton, Rosecrans, Rossville, Round Lake, Roxana, Russellville, St. Charles, St. Jacob, St. Joseph, Salem, Sandoval, Savanna (USPHS), Scott Field, (USPHS), Seneca (USPHS), Seymour, Shawneetown, Skokie, Springfield, Starved Rock State Park, Sugar Grove, Sullivan, Thomson, Urbana, Utica, Venedy Station, Vienna, Viola, Volo, Wadsworth, Waltersburg, Ware, Watseka, Wauconda, Waukegan, Wedron, West Vienna, Wetaug, White Heath, White Pines Forest State Park, Willow Springs, Winnetka, Wolf Lake, Woodstock, Yorkville, and Zion.

Subgenus *Taeniorhynchus* Arribáizaga

4. *Aedes sollicitans* (Walker)

LARVA.—Fig. 98. Head fairly wide, with short, tufted preantennal hairs and usually single (rarely double) upper and lower hairs, the lower hairs almost directly anterior to upper ones and without intervening tufts. Eighth segment with comb forming an irregular scattered triangle, composed of about 14 to 20 small scales. Air tube short and robust, two to two and one-half times as long as wide; hair tuft multiple branched, situated beyond pecten, and of moderate length; pecten forming a close and even series of about 20 teeth, the apical two or three usually more widely separated than the others. Anal segment completely ringed with sclerotized plate; anal gills very short, budlike.

FEMALE.—Length of wing 4.5 mm. Beak black, with a wide white band near middle, palps black tipped with white, dorsum of head golden. Mesonotum predominantly golden-brown scaled, the lateral areas and sometimes a mesal stripe darker brown. Pleurae with many white scales. Abdomen with tawny scales forming a fenestrated pattern made up of narrow basal bands and a wider mesal band of tawny scales against a blue-black background, very similar to

fig. 119; lateral portions of tergites each with a patch of white scales contrasting noticeably with the tawny scales; venter with a mixture of white and tawny scales. Legs, fig. 130, for the most part with a salt-and-pepper mottling of tawny scales and black scales; tarsi definitely banded with the apical portion black scaled, the basal portion white scaled. Hind tarsi with apical segment almost entirely white scaled, second, third, and fourth segments each with a basal band of white scales that cover a third to a half of the segment; basal segment with a basal band of white scales and a central band of tawny scales, the latter about as long as half the segment. Wings with a mottled appearance, the scales along all the veins being a salt-and-pepper mixture of dark scales and light scales.

MALE.—Similar in general to female with the following differences: beak without a definite band, the apical two-thirds being chiefly tawny scaled; palps very long and with distinct apical brushes, the basal segment being mostly tawny scaled. Male genitalia, fig. 138, of a very simple type. Basistyle nearly parallel sided, with a slight indication of a basal lobe, bearing at this point a cluster of hairs. Claspettes of moderate length, with a long apical blade curved at apex.

This species was recorded from Illinois by Chandler (1920) and by Matheson (1930), and has since been taken at a few scattered localities. Each occurrence has been associated with salt water from mine or oil well drainage. In two instances, at Dupo and at Central City, the species occurred in tremendous numbers. The severe and persistent biting led in each case to the organization of local control measures. In the Dupo area the salinity of water in which breeding occurred was three times the average for ocean water.

Like *vexans*, this species is an intermittent breeder. The eggs, which are laid in dry places, hatch at subsequent floodings, and there are new outbreaks of adults following most summer rains. The larvae develop very rapidly after hatching, and a wave of adults follows in quick succession.

ILLINOIS RECORDS.—Many larvae, collected March 18 to October 27, and adults, collected April 29 to October 14, are from Benton, Cahokia (USPHS), Carterville (USPHS), Central City, Centralia, Chanute Field (USPHS), Crab Orchard Lake (USPHS), Dupo, Granite City (USPHS), Herrin, Johnston City (USPHS), Law-

renceville (USPHS), Mount Vernon (USPHS), Savanna (USPHS), Scott Field (USPHS), West Frankfort, White City (USPHS), and White Heath (USPHS).

5. *Aedes nigromaculis* (Ludlow)

LARVA.—Head similar to that of *sollicitans*, having upper and lower head hairs single. Eighth segment with comb forming an irregular scattered triangle composed of 14 to 20 scales. Air tube short and robust, two to two and one-half times as long as wide; hair tuft beyond pecten multiple branched and short; pecten occupying most of the length of the tube with several conspicuously detached teeth at the apex. Anal segment completely encircled by sclerotized ring. Anal gills twice as long as anal segment, pointed, representing the chief difference between this species and *sollicitans*.

ADULTS.—In length and color almost identical with those of *sollicitans*, differing in the coloration of the abdomen, in which the dorsal, mesal, and lateral bands of pale scales are all practically pure white. The width of the white band on the beak and the central band of pale scales on the hind basitarsus both vary considerably, sometimes represented by only a few pale scales. No characters have yet been found to separate satisfactorily the male genitalia of *sollicitans* and *nigromaculis*.

A western species, *nigromaculis* has so far been taken only once in Illinois. A single female was caught in the light trap at the Savanna Ordnance Depot, July 7, 1945, and collected by S. Mittler. This record was first discovered by Captain Charles F. Gerlach, U. S. Public Health Service, to whom I am greatly indebted for information regarding it.

No larvae of this species have yet been taken in the state. The species frequents saline pools throughout the great plains area and westward.

6. *Aedes mitchellae* (Dyar)

LARVA.—Head similar to that of *sollicitans*. Eighth segment with comb more compact than in *sollicitans*. Air tube somewhat slender, more than three times as long as wide; hair tuft usually seven branched, situated beyond pecten; pecten composed of a close row of small teeth. Anal segment completely ringed by sclerotic shield; anal

gills slender and pointed, slightly longer than anal segment (after Dyar).

FEMALE.—Similar in size and almost all particulars of color and structure to the female of *sollicitans*, differing chiefly as follows: hind basitarsus having no center band of tawny scales, being black scaled with a basal band of white scales; tibiae predominantly black with a conspicuous scattering of white scales on the anterior face; wings entirely dark scaled.

MALE.—Genitalia, fig. 136, very similar in most particulars to those of *sollicitans*, differing chiefly in the round and projecting basal lobe. The setae on this lobe are longer than in *sollicitans*.

This species is primarily southeastern in distribution. Our only record for Illinois is a single female collected on the south side of Chicago, May 18, 1906, by Charles A. Hill; it was recorded as *Aedes taeniorhynchus* (Wiedemann) by Gerhard in 1910. The lack of subsequent records indicates strongly that it represents an adventive. The specimen probably came north by train.

Subgenus *Aedes* (Meigen)

7. *Aedes cinereus* Meigen

LARVA.—Fig. 101. Head wide and relatively short; upper and lower hairs each with four to seven filaments, the lower hair almost directly laterad of the upper hair and only slightly anterior to it; no accessory tuft between or in front of upper and lower pairs. Eighth segment with comb forming an irregular line or an irregular triangle of 10 to 15 large well-separated teeth. Air tube moderately elongate, about four and one-half to five times as long as wide; hair tuft short, usually quadruple, situated beyond pecten; pecten with about 14 teeth, the basal ones very small, the apical ones very long and widely separated. Anal segment with the tergite encompassing only about one-half the segment; anal gills slender and sharp, about as long as the air tube.

FEMALE.—Length of wing 4 mm. Head, including beak and palps, dark brown to black. Mesonotum entirely reddish-brown scaled with a few postero-lateral and postero-mesal areas of grayish scales. Abdomen with dorsum almost entirely bluish-black scaled, the base of each segment with a narrow crescent of cream scales at the base; venter of abdomen almost entirely white or cream scaled. Legs with tibiae and

tarsi entirely bluish-black scaled, the femora with the anterior faces usually dark, the posterior faces whitish. Wings entirely dark scaled.

MALE.—In size and general color similar to female. Palps represented by short stubs, very similar to those of the female and entirely unlike those of any other Illinois species of the genus. Abdomen with basal white bands more pronounced than in the female. Male genitalia, fig. 135, differing from all others in the genus by the following distinctive characters: dististyle inserted some distance from the apex of the basistyle; dististyle with prominent sclerotized processes at base and having apex divided into a Y-shaped fork; basistyle with a pointed, projecting apex, a broad base bearing a sharp basal lobe, and also a branched sclerotized mesal lobe; claspettes entirely lacking.

This mosquito, which is crepuscular and a ready biter in the vicinity of its larval habitat, is common in the many small water holes that abound in the glacial bogs and marshes in the northeastern corner of the state. Apparently it produces annually only one generation, which emerges in late May or early June.

Aedes cinereus was formerly known under the name of *fuscus* Osten Sacken, and a specimen was so recorded from Glen Ellyn, Illinois, May 30, 1908, by Gerhard (1910). In addition to many records of the species from northeastern Illinois, we have scattered records from other parts of the state, especially the southern fourth. The records from southern Illinois were associated with (but not reared from) woodland pools.

Illinois Records.—Antioch, Cahokia (USPHS), Cairo (USPHS), Camp Grant (USPHS), Carterville (USPHS), Crab Orchard Lake (USPHS), Chemung, Elgin, Glencoe, Gorham, Great Lakes Naval Training Station, Kankakee, Keithsburg, Lawrenceville (USPHS), Pingree Grove, Ravinia, Roxana, Scott Field (USPHS), Skokie, Springfield (USPHS), Volo, Wauconda, Waukegan, and Zion.

Subgenus *Ochlerotatus* Arribáizaga

8. *Aedes excrucians* Walker

LARVA.—Fig. 103. Length 10 mm. Head wide. Lower head hairs usually double, upper head hairs usually triple, but frequently double, and any of the four occasionally single. No accessory hairs or tufts between them. Air tube elongate, about

five times as long as wide; pecten with one to three apical teeth detached, ventral tuft situated beyond the pecten and very long. Lateral comb consisting of an irregular patch of about 25 scales. Anal segment with dorsal shield covering little more than one-half the segment, the anal gills about as long as the segment, narrow and tapering.

FEMALE.—Length of wing 6 mm. In color and general characteristics, this species is very similar to *stimulans*, differing as follows: mesonotum usually with much more extensive reddish-brown areas and meso-epimeron without bristles.

MALE.—In color and general structure similar to male of *stimulans*. Genitalia, fig. 155; similar in general proportions to those of *stimulans* but differing markedly as follows: ventral aspect of basistyle seeming to have basal lobe projecting as a triangular area; in reality the basal lobe is a large and somewhat rectangular area folded back against the mesal face, covered with rows of short fine setae and without any indication of a macrochaeta.

To date we have found this species in only the northeastern corner of the state, where it inhabits the spring pools in some of the marshes and bogs. It appears to favor marsh situations that border woods and is found usually in company with *stimulans* and *fitchii*. It has only a single generation per year, and its habits are very similar to those of *stimulans*. We have never found it in Illinois in the tremendous numbers that characterize colonies of *stimulans*. Matheson (1930) recorded the species from several localities in northeastern Illinois. In addition, he gave a record from Urbana, which is in the central part of the state; this specimen, however, appears more like *fitchii*, although it is in very poor condition and does not provide a good basis for a definite record.

Aedes excrucians is Holarctic in distribution. In North America it is restricted to the northern coniferous forest belt and areas a short distance southward. Our Illinois records appear to be on the southern limit of its range in this longitude.

Illinois Records.—BEACH: June 10, 1933, Mohr & Townsend, 1♀. ELK GROVE: May 2-6, 1942, 11♂, 21♀, 6 larvae. Volo: April 24, 1942, Ross & Burks, April 29, 1942, Ross & Samuels, 12 larvae; May 4-5, 1942, Ross & Burks, 1♀, 5 larvae. WADSWORTH: June 3, 1943, Ross & Sanderson, 8♂; June 10, 1942, Ross & Sanderson, 17♂, 1♀. WAUCONDA:

April 21, 1942, Ross & Riegel, 1 larva; April 29, 1942, 3 ♂.

9. *Aedes flavescens* Müller

LARVA.—Head wide, upper and lower hairs multiple, the upper ones sometimes double. Eighth segment with comb forming a triangular patch of scales. Air tube over three times as long as wide, the pecten reaching the middle, with the last two teeth detached. Anal segment with dorsal plate covering only the dorsal half of the segment. Anal gills as long as the anal segment and tapering to a point.

FEMALE.—Length of wing 7 mm. Head and mesonotum golden brown with areas shading to a more yellowish cast. Beak and palps black with white scales scattered along the entire length. Dorsum of abdomen entirely cream scaled. Legs, except for the tarsi, mostly cream scaled. Basitarsus a mixture of white and black scales, the apical tarsal segments with the basal halves entirely white scaled, the apical halves dark scaled. Wings almost entirely cream scaled with a few black scales mixed in with them.

MALE.—In size and general color similar to female, palps with an apical brush. Genitalia, fig. 152, as follows: apical lobe large and projecting; basal lobe large and triangular, with many short setae and a single large conspicuous macrochaeta; claspette having a short stout base with fairly long apical filament, and beyond this a long narrow neck and enlarged apical head which tapers to a narrow tip.

To date we have taken only isolated adults of this species from the state, all from the northeastern portion, from near the Wisconsin border to Kankakee, some 100 miles farther south. The males we took in the vicinity of marshes in which the larvae probably breed.

Our records for this species, which is Holarctic in distribution, are on the southern edge of its range. The Illinois records given by Matheson (1930) for this species from Algonquin prove to be for *fitchii*, but our present records from Franklinville and Woodstock are close to Algonquin. The species is believed to have only one generation per year and the adults seldom are abundant enough to be a nuisance.

Illinois Records.—ANTIOCH: May 21, 1941, 1 ♂, 1 ♀. FRANKLINVILLE: June 4, 1943, marsh

pond, Ross & Sanderson, 1 ♂. KANKAKEE: Aug. 4, 1938, Burks & Boesel, 1 ♀. WOODSTOCK: June 4, 1943, cattail marsh, Ross & Sanderson, 1 ♂. ZION: June 19, 1941, 1 ♀; June 10, 1942, Mohr & Burks, 1 ♀.

10. *Aedes stimulans* Walker

LARVA.—Fig. 104. Length 9 mm. Head wide, lower head hairs usually single, rarely double, upper head hairs usually double but occasionally single, triple, or quadruple. Eighth segment with lateral comb forming a rough triangle of about 30 scales. Air tube about three and one-half times as long as wide; pecten composed of an even series, the ventral tuft situated beyond it, usually three haired, and longer than width of segment at base of tuft. Dorsal shield covering little more than half of segment; gills pointed and usually slightly shorter than segment.

FEMALE.—Length of wing 6 mm. Beak and palps with a mixture of brown scales and white scales. Mesonotum varying from grayish brown to reddish brown, with gray-scaled stripes or areas along the lateral half and always nearly covering the scutellum. Mesopleurae with a group of three to six epimeral bristles. Dorsum of abdomen mostly dark scaled, each segment with a basal band of white scales, the bands small and crescentic on the basal segments, becoming wider and more extensive toward the apex. Hind tarsi with basal segments mostly white scaled; second, third, and fourth dark scaled with a basal white band occupying about a third of the segment. Wings mottled with brown scales and white scales, the dark ones predominating.

MALE.—Similar to female in color and structure. Palps with apical brushes. White bands on abdomen usually much more extensive. Male genitalia, fig. 153: basistyle with well-developed apical lobe; basal lobe developed as a large mesal lobe bearing many short setae and a large macrochaeta, but projecting only slightly as seen from ventral view; claspette curved and narrow, its apical filament elongate with a long slender base, a sharp upper projection near middle, and from this point gradually tapering to a slender curved tip.

Three *Aedes* species, *stimulans*, *exrucians*, and *fitchii*, form a group the females of which are frequently difficult to identify. The characters given in the key are not infallible, but will serve to separate most

specimens. Characters of larvae and of male genitalia offer very satisfactory means of diagnosis.

Aedes stimulans occurs in tremendous numbers in and near woodland pools and stump holes in the northeastern corner of Illinois. The larvae, which appear shortly after the annual spring thaw, develop slowly, but are usually full grown by the time the first warm weather of late May occurs. The adults soon emerge, and during June and early July many woods in the vicinity of northeastern Illinois are teeming with ferocious biters. The species has only one generation per year. Outside of the northeastern corner of the state, we have records of isolated colonies as far south as the central portion of the state. Early records of about 1906 and 1910 indicate that this species may have been much more abundant in central Illinois during the early part of the century, before so many extensive tracts of upland timber were cleared.

The range of *stimulans* is widespread throughout the northeastern states, across the north central states, through Canada, and into the Yukon. Illinois is on the southern limit of its range.

Illinois Records.—Larvae, collected April 15 to April 25, and adults, collected April 28 to July 20, are from Algonquin, Antioch, Bensenville, Bishop, Camp Grant (USPHS), Elk Grove, Glencoe, Gurnee, Halfday, Highwood, Momence, Muncie, Northmoor, Palatine, Princeton, Ravinia, River Forest, Rockford, Rock Island, Rondout, Rosecrans, Starved Rock State Park, Urbana, Utica, Volo, Wadsworth, Waukegan, Yorkville, and Zion.

11. *Aedes fitchii* Felt & Young

LARVA.—Fig. 109. Length 9 mm. Head wide, lower hairs usually double, occasionally single or triple, upper hairs usually triple, occasionally double, and rarely quadruple. Lateral comb somewhat triangular, composed of about 25 scales. Air tube elongate, about five times as long as its width near middle of pecten, tapering markedly and gradually from base to apex; pecten consisting of 20 to 25 scales forming an even row; ventral tuft situated just beyond pecten and very long. Anal segment with dorsal shield covering nearly two-thirds of segment; anal gills longer than segment and pointed.

FEMALE.—Length of wing 6 mm. Color and general structure in general as for *stim-*

ulans with the following diagnostic features: head gray, mesonotum with the mesal third bright reddish brown, the lateral third hoary gray with a few reddish-brown scaled areas, scutellum gray; meso-epimeron usually with only two bristles.

MALE.—In size and general color similar to female. Genitalia, fig. 154: basistyle with projecting rod, apical lobe bearing a scattering of long setae projecting mesad; basal lobe large and bearing a dense cluster of very fine long setae, in addition to the basal macrochaeta. Claspette with basal portion nearly straight, the apical filament short and curved, bladelike, and with its underside notched at the extreme base.

Both Gerhard (1910) and Matheson (1930) recorded this species from Illinois. Most of our recent records for it are from the northeastern corner of the state. Here the species breeds in abundance in practically every open marsh. It is usually found associated with *Culiseta inornata* or *Aedes excrucians*, but in some marshes it occurs as a pure colony. Our only records south of northern Illinois were obtained by Hart from Urbana in 1887 and from Havana in 1892. We have a recent record taken from Savanna, which is in the extreme northwestern part of the state. The species has apparently only one generation per year.

Our Illinois records appear to be on the southern limit of the range of this species, which has a wide northern distribution similar to that of *stimulans*.

Illinois Records.—Larvae, collected April 29 to June 10, and adults, collected May 3 to October 5, are from Algonquin, Antioch, Elk Grove, Franklin (Cook County), Franklinville, Glencoe, Great Lakes Naval Training Station, Halfday, Lake Bluff, Orland Park, Palos Park, Ravinia, River Forest, Sand Lake, Savanna, Urbana, Volo, Wadsworth, Waukegan, Willow Springs, Woodstock, and Zion.

12. *Aedes thibaulti* Dyar & Knab

LARVA.—Head, fig. 97, wider than long; preantennal and both upper and lower head hairs long, the lower head hairs usually quadruple, the others with five or more branches; clypeal hairs very wide apart, three-quarters as far apart as distance between upper head hairs; lower head hairs considerably laterad of and only slightly anterior to upper hairs; antennae very long, over three-quarters as long as head, antennal tuft very long. Eighth segment with comb

consisting of a trianguloid patch of scales. Air tube about four and one-half times as long as wide, with pecten consisting of about 20 scales arranged in an even row, ventral tuft situated just beyond pecten, usually six branched, the branches longer than the greatest width of the tube. Anal segment with dorsal shield longer than wide, covering about two-thirds of the segment; anal gills about as long as segment, tapering to a blunt tip.

FEMALE.—Length of wing 4 mm. Beak and palps black, head gray. Mesonotum, fig. 122, with a bluish-black mesal patch that is narrow on the anterior half of the mesonotum but that on the posterior half occupies nearly the entire width of the segment. Antero-lateral areas of the mesonotum are a bright gray, with scales long and slender and not forming a shingled patch; abdomen bluish black with small white lateral patches at the bases of most of the segments; legs with tibiae and tarsi entirely black, femora with anterior and apical portions black, with conspicuous white knee rings and white basal areas; wings entirely brownish-black scaled.

MALE.—Similar in size and color to female; palps very long and with apical brushes. Male genitalia, fig. 139, with broad basistyle that has a prominent apical and basal lobe and peculiar claspettes; the claspette blade is contorted into a somewhat irregular hook-shaped structure unlike that of any other North American species in the genus. Otherwise, the species shows a marked affinity to *trivittatus*, on the basis of the small but definite apical and basal lobes of the basistyle.

Published records indicate that this species is primarily a south central species and has been found in abundance in Arkansas. The Illinois records represent the most northern locality in which the species has been taken. An excellent account of its life history is given by Horsfall (1940). It usually breeds in holes within the bases of standing trees. It seems to prefer swamp situations and, according to some writers, shows a marked preference for the bases of sweet gum and tupelo gum trees.

Illinois Records.—CAHOKIA: June 29, 1943, Snow, 1♂ (USPHS). CARTERVILLE: June 27, 1942, 1♀ (USPHS); May 31, 1944, 1♀ (USPHS). MARION: June 2, 1942, Johnson, 1♂ (USPHS). SCOTT FIELD: June 25, 1942, 2♀ (USPHS); June 16, 1943, 2♀ (USPHS); June 18, 1943, 1♀ (USPHS).

13. *Aedes grossbecki* Dyar & Knab

LARVA.—Fig. 113. Length 10 mm. Head wide, lower hairs usually double or triple, upper hairs usually triple, sometimes double or quadruple. Lateral comb of segment 8 forming a triangular patch consisting of about 30 scales. Air tube three and one-half times as long as wide, tapering only slightly; pecten teeth forming an even row; ventral tuft situated just beyond pecten and as long as, or slightly longer than, width of air tube at base of tuft. Anal segment with dorsal shield covering about one-half of segment; anal gills about as long as segment and tapering.

FEMALE.—Length of wing 5 mm. Beak and palps black, with scattered white scales, each palp with a small tuft of white scales at apex; dorsum of head covered with gray and white scales. Mesonotum with an irregular pattern, fig. 118, the lateral area white scaled, the mesal third of the anterior half bright brown scaled and the major portion of the disc of the posterior half black scaled, the posterior border white scaled; these areas are variable and merge one into another. Dorsum of abdomen irregularly scaled, the ground pattern dark scaled with a scattering of white scales, and each segment with an arcuate basal area of white scales. Legs, fig. 124, mostly white scaled, the middle and posterior pair with irregular areas of black scales; hind tarsi banded, segments 2 to 5 with basal third to half white scaled, apex black scaled, basitarsus mostly white scaled but not definitely banded. Wings with a mixture of white scales and black scales. All the wing scales are very wide, fig. 169, a characteristic that sets off this species from all other Illinois members of the genus.

MALE.—In size, color, and wing scaling similar to female. Palps with large apical brushes. Male genitalia, fig. 157: basistyle with projecting apical lobe bearing several rows of hairs curved dorsad; basal lobe wide and steplike, the macrochaeta somewhat isolated on the ventral edge, the remainder with a cluster of long setae; claspettes with base curved, apical filament with a slender base and an expanded apex that tapers to a curved sharp tip.

Although not abundant, this species is common throughout the post oak flats along the Mississippi River in extreme southern Illinois. Outside this area only isolated

specimens have been taken, but these extend the known range in the state north as far as Chicago. The only Chicago record is that of Gerhard (1910), who recorded a male from Chicago and a female from Palos Park under the name *Aedes sylvicola* Grossbeck (now considered a synonym of *grossbecki*). The adults of *grossbecki* emerge early in the spring and apparently have only one generation per year. Outside of Illinois the species has been recorded from only a few localities to the South. We have encountered the adults in the field so rarely that we know little of their habits.

Illinois Records.—Several larvae, collected April 3, and adults, collected April 6 to June 17, are from Cache, Crab Orchard Lake, Gorham, Grand Tower, La Rue, Mount Vernon, Reynoldsville, St. Jacob, Urbana, and Ware.

14. *Aedes trivittatus* Coquillett

LARVA.—Fig. 108. Head fairly wide, upper and lower head hairs always long and single; preantennal hair short and eight-branched; accessory hairs absent. Eighth segment with a triangular comb consisting of short pointed scales. Air tube fairly short and robust, about two and one-half times as long as wide; hair tuft fairly short and six to eight branched, situated beyond apex of pecten; pecten consisting of about 15 fairly long teeth arranged in an almost perfectly regular row. Anal segment completely ringed by sclerotic plate; anal gills long and tapering, frequently twice length of anal segment.

FEMALE.—Length of wing 5 mm. Beak and palps black, dorsum of head white scaled. Mesonotum, fig. 115, with a long dark central wedge, flanked on the side by a wide stripe of white scales; the anterior portion of the mesonotum has a dark stripe laterad of the light stripe. Dorsum of abdomen almost entirely dark scaled with small lateral triangles of white scales on the apical segments; venter almost entirely white scaled with black lateral triangles on basal segments. Femora pale scaled with stripes of black scales on apical areas; tibiae and tarsi dark scaled with narrow lines of whitish scales on the ventral edge; wings entirely dark scaled.

MALE.—In size and color similar to female. Male genitalia, fig. 151: basistyle with apical lobe only moderately developed, shoulderlike; basal lobe steplike, with a

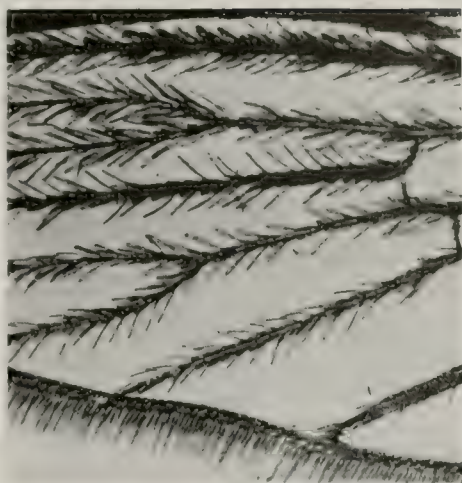


Fig. 168.—Portion of wing of *Aedes stimulans*.

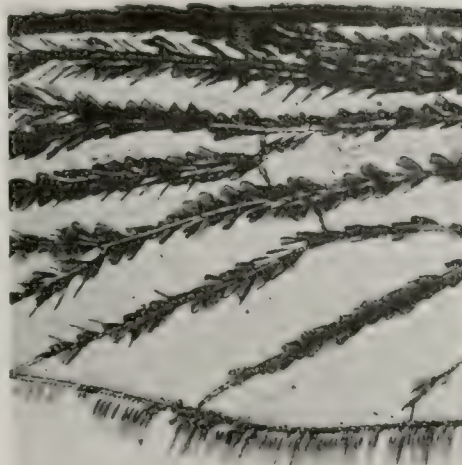


Fig. 169.—Portion of wing of *Aedes grossbecki*. Note the wide scales on the veins compared with those of fig. 168.

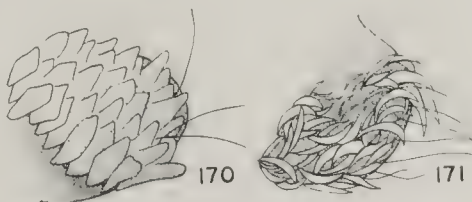


Fig. 170.—*Aedes triseriatus*, scales on pro-notal lobe, lateral aspect.

Fig. 171.—*Aedes thibaulti*, scales on pro-notal lobe, lateral aspect.

very sinuate macrochaeta and many long slender setae. Claspette curved, its apical filament with a definite neck and head, the back of the head produced into one to several spinelike barbs, the tip slender and slightly hooked.

The male of this species is very similar in many respects to that of *infirmatus* Dyar & Knab. In *infirmatus*, fig. 150, the macrochaeta of the basal lobe has a definite thickened angle near the base, the basal lobe itself is diagonal to the main axis of the basistyle, and the basistyle is more slender. The claspettes of the two species are very similar.

Aedes trivittatus is one of the extremely annoying species encountered in Illinois. It is a fierce biter, even in the day time, and occurs in a wide variety of temporary pool situations. The adult emergence apparently occurs principally during the late spring, generally later than that of *sticticus* and *canadensis* and frequently coinciding with that of *vexans*. The larvae have been found in shady woodland pools usually resulting from spring rains or spring floods. In our recent collecting, the adults have been encountered in great numbers many times, but the larvae have been taken very seldom and only in small numbers.

In Illinois this species is distributed fairly uniformly over the entire state. Its range covers the northeastern and north central states with a few records extending into the southern states.

Illinois Records.—Larvae, collected May 8 to September 17, and many males and females, collected May 4 to November 29, are from Antioch, Baker, Cahokia (USPHS), Camp Grant (USPHS), Carterville (USPHS), Champaign, Chicago, Crab Orchard Lake (USPHS), Danville, Des Plaines, East Peoria (USPHS), East St. Louis, Edwardsville, Glencoe, Great Lakes Naval Training Station, Halfday, Havana, Herod, Homer, Joetta, Kappa, Keithsburg, Lake Fork, Mascoutah, Matanzas Lake, Momence, Muncie, Neoga, New Boston, Oakwood, Pere Marquette State Park, Princeton, Ravinia, St. Jacob, Savanna (USPHS), Scott Field (USPHS), Seneca (USPHS), Seymour, Springfield, Starved Rock State Park, Sycamore, Urbana, Utica, Wadsworth, Ware, Weldon Springs, and Zion.

15. *Aedes aurifer* Coquillett

LARVA.—Fig. 100. Head wider than long, clypeal bristles moderately far apart. Antennae very long, nearly as long as length of

head, the tuft distinctly beyond middle of antennae and the apical portion markedly more slender than the basal portion. Upper and lower head hairs usually double, occasionally one of them triple, each lower head hair at least twice as far laterad as it is anteriad of upper head hair. Eighth segment with comb varying from an irregular single or double row of about 10 scales to an irregular patch of about 20 scales. Air tube nearly four times as long as greatest width; pecten with 12 to 20 scales, the basal ones very short and broad, the apical 2 or 3 detached from the remainder; ventral tufts multiple and markedly longer than greatest width of tube. Anal segment not completely ringed by sclerotized plate, but with a ventral membranous strip about as wide as in fig. 110B. Gills tapering and of moderate length.

FEMALE.—Length of wing 4 mm. Beak and palps black, head varied with golden and dark brown. Mesonotum, fig. 123, having a large central purplish-black area with narrow lateral areas of gray scales shading to gold where the lateral and mesal areas meet, scutellum with a small gray area flanked on each side with a short and very narrow golden line. Dorsum of abdomen almost entirely bluish black, the lateral portion of each tergite having a white patch just visible from dorsal view. Legs with tibiae and tarsi almost entirely blue black, some of the scales gray; femora with apical and dorsal portions black, extreme apex of each with a small white knee spot, basal portion cream. Wings entirely bluish-black scaled.

MALE.—In size, color, and general structure similar to female. Palps with a large apical brush. Male genitalia, fig. 141: basistyle moderately narrow with a large tuft of long conspicuous setae at apex; apical lobe set off as a shoulder, its dorsal margin with an irregular linear area of setae curving dorsad; basal lobe represented by a detached sclerotized plate on the mesal face of the basistyle, this sclerite with a scattering of short setae and a single large dorsal macrochaeta arising from the dorsal margin; claspette with a short curved base, the apical blade long, bearing a large barb on its upper surface and tapering to a slender curved apex.

The male genitalia of this species are of the same type as those of *intrudens* Dyar, fig. 142. The two differ somewhat in details

of the claspette and apical tuft of the basistyle, but more particularly in the basal lobe. In *intrudens* the basal lobe bears three macrochaetae, one at the extreme base and two on the dorsal margin.

The range of *aurifer* extends throughout the northeastern and north central states. We have only a single record of the species for Illinois, a female taken in the vicinity of a cypress swamp at Karnak, May 15, 1941, by Mohr & Burks. This specimen was collected considerably south of other *aurifer* records in the western portion of the range of the species. The distinctive color markings of this specimen check perfectly with the markings of specimens from Michigan and Rhode Island.

16. *Aedes dorsalis* Meigen

LARVA.—Head fairly wide; upper and lower head hairs long, always single, the lower hairs almost directly anterior to the upper ones and without intervening tufts. Eighth segment with comb triangular, composed of small sharp scales. Air tube moderately stout, two and one-half to three times as long as wide, hair tuft about six branched, situated beyond pecten; pecten with about 20 teeth forming an evenly spaced row. Anal segment with sclerotic shield covering only dorsal half of segment; anal gills very short and budlike.

FEMALE.—Length of wing 4.5 mm. Most of body and appendages cream to tawny scaled; beak tawny brown; mesonotum tawny; usually with a narrow brown mesal stripe and another brown stripe along each lateral margin, fig. 119, sometimes with additional narrow brown stripes and sometimes without any brown stripes; abdomen cream scaled, the basal segments usually each with a pair of lateral spots of dark scales. Legs mostly cream scaled with a mixture of black scales, especially toward the apexes of the femora; tarsi mostly black scaled with a white fringe at the base and apex of each segment. Wings cream scaled, usually but not always with an irregular mixture of black scales on most of the veins.

MALE.—In color similar to female except that the brown stripes on the mesonotum are usually darker and wider. The palps have apical brushes as in *canadensis*. Genitalia, fig. 145, as follows: basistyle with apical lobe only moderately developed and square shouldered; basal lobe projecting

and round, with one short and one long macrochaeta and with many slender setae; these setae are very short near the macrochaetae and increase in size to the dorsal margins of the lobe, fig. 145B; claspettes with slender bases, the apical filament of each angled near middle and tapering to a slender tip.

This species is similar in general appearance to *Aedes campestris* Dyar & Knab. The males, however, differ markedly in the setation of the basal lobe. In *campestris*, fig. 146, this lobe bears long setae of almost equal length over the entire surface and has only a single macrochaeta, which is little larger or longer than the other setae. The females are practically impossible to identify; in the past it has been considered that in *dorsalis* the third vein (R_{3+4}) was almost entirely dark scaled whereas in *campestris* this vein was largely white scaled. Reared series from individual colonies have shown that this differentiation does not hold, since both extremes and various intermediate conditions occur in *dorsalis* alone.

The first Illinois reports of *dorsalis* were from the suburbs of Chicago and were recorded by Gerhard (1910) using the name *Aedes curriei* Coquillett, a name then in use for this species but since that time sunk as a synonym of the Holarctic *dorsalis*. The species was reported from Oak Park, Illinois, by Matheson (1930) as *Aedes dorsalis*. At the same time Matheson recorded four females of *Aedes campestris* from Riverdale, near Chicago, Illinois. There seems no doubt that these Riverdale specimens are true *dorsalis* and not *campestris*, because all males taken in the Chicago area have proved to be *dorsalis*, and these specimens come well within the range of variation of reared series from nearby localities.

Only a few colonies of *dorsalis* have been found in the state, and all have been associated with waters contaminated by industrial wastes. In southern Illinois, one colony occurred with *solicitans* in saline water from oil wells, and in northern Illinois other colonies were in the seepage areas from several factories. The species is an irregular, intermittent breeder, and usually a brood of adults emerges following each inundation by rain of the affected areas.

The adult females are fierce biters and appear to be predominantly crepuscular.

Illinois Records.—Larvae, collected April 22 to May 9, and adults, collected April 9 to

October 10, are from Cahokia (USPHS), Camp Grant (USPHS), Chanute Field (USPHS), Dupu, East Moline, East St. Louis, Great Lakes Naval Training Station, Oak Park, Riverdale, Savanna (USPHS), Scott Field (USPHS), and Summit.

17. *Aedes canadensis* Theobald

LARVA.—Fig. 105. Head wide; upper and lower hairs multiple, five to eight branched, similar in length and fanlike appearance to preantennal hairs. Eighth segment with comb somewhat triangular, composed of a large number of small scales. Air tube moderately slender, nearly four times as long as wide; hair tuft long, usually five branched; pecten forming an even row of about 15 teeth, the apical teeth slightly wider apart than the others. Anal segment with sclerotic shield covering only the dorsal half of the segment; anal gills tapering and pointed, about as long as the segment.

FEMALE.—Length of wing 4 mm. Beak and palps brown, the latter with a minute tuft of white scales at extreme tip. Mesonotum uniformly golden brown and with a few indistinct gray lines along lateral margins and on or near scutellum. Dorsum of abdomen dark scaled with an almost uniform narrow band of white scales at base of each segment. Tarsi each with a fairly wide band of white scales at both base and apex, tibiae almost entirely dark scaled, femora mostly white scaled with dorsal portions dark scaled. Wings uniformly bluish-brown scaled.

MALE.—Similar in size, color, and general characters to female, differing chiefly in the long palps, each of which extends beyond the beak and has a large apical brush embracing the last two segments and the apex of the preceding segment. The white bands on the dorsum of the abdomen are much wider than in the female. Genitalia, fig. 140: basistyle with large ovate apical lobes bearing a dense cushion of flattened wide setae, basal lobes wide and triangular, with a uniform brush of very slender setae and a larger single macrochaeta at base; dististyle elongate, with an apical seta; claspette moderately long and stout, with a slender sinuate filament.

This species, which is one of the most widespread in the state, has only one generation per year. The larvae mature early in

the season; the adults emerge in April and May. The species frequents chiefly woodland pools, especially those flooded by seepage water in the spring independent of high water in the streams. In southern Illinois, it occurs primarily in the post oak flats along the Mississippi. In other parts of the state it is found in stump holes, small sink holes, and isolated oxbows of small woodland streams. In rare instances it is found in practically unshaded situations.

The females are fierce biters and attack readily in shaded situations through most of the day. They live for many months, and, in woodland situations, isolated specimens are encountered well into the summer. To date the species has not been incriminated as a carrier of disease.

Illinois Records.—Larvae, collected March 18 to May 23, and many males and females, collected April 11 to August 1, are from Alpha, Altamont, Antioch, Bensenville, Benton, Cache, Camp Grant (USPHS), Carbondale, Carterville (USPHS), Casey, Centralia (USPHS), Cottage Grove, Crab Orchard Lake (USPHS), Danville, Darwin, Des Plaines, Effingham, Elgin, Elk Grove, Equality, Giant City State Park, Glencoe, Golconda, Gorham, Grand Tower, Grantsburg, Grimsby, Halfday, Herod, Ina, Johnston City (USPHS), Jonesboro, Kankakee, Karnak, La Rue, Marion, Mascoutah, Mokenca, Mount Vernon, Muncie, Oakwood, Raven, Ravinia, Reynoldsville, Rondout, St. Jacob, Salem, Scott Field (USPHS), Springfield, Starved Rock State Park, Urbana, Utica, Vienna, Volo, Wadsworth, Waltersburg, Ware, Waterloo, Wauconda, West Vienna, Willow Springs, Yorkville, and Zion.

18. *Aedes sticticus* (Meigen)

LARVA.—Fig. 107. Length 8 mm. Head with upper and lower hairs of only moderate length, usually two to four branched but occasionally with an odd hair single, the exact combination of branching extremely variable and frequently asymmetrical; lower head hairs almost directly anterior to upper hairs. Eighth segment with comb triangular, composed of small scales. Air tube fairly short, about two and one-half times as long as wide; hair tuft short, usually six branched; pecten with 15 to 20 teeth arranged in a close, evenly spaced row. Anal segment with sclerotic plate covering about three-fourths of segment; anal gills tapering and pointed, about as long as anal segment.

FEMALE.—Length of wing 4 mm. Beak and palps black, the beak with a small group of gray scales at apex; dorsum of head gray scaled. Mesonotum, fig. 116, with a broad mesal brown band extending from anterior margin to scutellum and divided down the meson by a very narrow line of gray scales; lateral bands of mesonotum and scutellar region gray; supplemental short brown bands are usually present on the posterior half of the lateral areas, these bands always short and separated from the mesal band by at least a definite line of gray scales. Dorsum of abdomen definitely banded, the apical two-thirds of most of the segments dark scaled, the basal third white scaled. Femora, fig. 125, mostly white scaled, the dorsal edge and apical portion of each black scaled; tibiae usually with upper and lower margins black scaled, sides predominantly pale scaled; tarsi predominantly black scaled, without banding, the posterior basitarsus with white scales often extending as irregular lines from base to near apex. Wings predominantly black scaled, the costal and subcostal areas frequently with many white scales mixed with the black ones.

MALE.—Size and general color as for female. Genitalia, fig. 148; basistyle with very large projecting apical lobe, which bears along its mesal edge a series of setae curved dorsad; basal lobe forming a triangular flap markedly detached from basistyle and connected with it chiefly by membranous folds, with a macrochaeta at extreme base, and with the apical portion curved and bearing fairly stout setae. Claspette slender, with a short apical filament that is expanded near base.

Holarctic in range, this species in North America is widely distributed from coast to coast. In much of the recent literature it has been called *hirsuteron* (Theobald) in the East and *aldrichi* Dyar & Knab in the West. Dr. Alan Stone writes me that he believes these two are the same species and should be considered under the name *sticticus*. Edwards (1932) has synonymized *aldrichi* with *lateralis* (Meigen). Dr. Stone writes that there is some doubt as to the identity of *lateralis* and believes it prudent to use *sticticus* for the species.

In Illinois *sticticus* is extremely common along the flood plains of the larger rivers, where it breeds in flood pools. At times individuals of the species appear in great swarms, and the females are ferocious biters

during the evening and also during the day in cloudy or shaded situations. Emergence of the adults occurs once a year, in early spring. The larvae seem to require shaded pools for development.

Illinois Records.—Larvae, collected April 3 to August 18, and many males and females, collected April 6 to October 25, are from Alto Pass, Belleville (USPHS), Billett, Bishop, Cache, Cahokia (USPHS), Cairo, Calvin, Camp Grant (USPHS), Carbondale, Carterville (USPHS), Casey, Caseyville, Charleston, Clinton, Crab Orchard Lake (USPHS), East St. Louis, Edwardsville, Fox Ridge State Park, Fulton, George Field (USPHS), Glencoe, Golconda, Gorham, Grafton (USPHS), Grand Tower, Granite City (USPHS), Grantsburg, Grayville (USPHS), Great Lakes Naval Training Station, Halfday, Havana, Herod, Homer, Hurst, Inman, Joetta, Johnston City (USPHS), Kankakee, Kappa, Karnak, Keensburg, Keithsburg, Lake Fork, La Rue, Lawrenceville (USPHS), Mascoutah, Matanzas Bay, Mokenca, Mount Carmel, Mount Vernon, (USPHS), New Boston, New Haven, Oakwood, Palestine, Palisades, Patton, Pere Marquette State Park, Pike, Pingree Grove, Prophetstown, Pulaski, Ravinia, Reynoldsville, Ridge Lake, Rising Sun, Rockford, Russellville, St. Jacob, Savanna (USPHS), Scott Field (USPHS), Shawneetown, Springfield (USPHS), Starved Rock State Park, Tamaroa, Urbana, Utica, Ware, West Vincennes, Willow Springs, Wolf Lake, and Zion.

19. *Aedes spencerii* (Theobald)

LARVA.—Length 8 mm. Head wide, both upper and lower head hairs almost always single but occasionally one of them double. Terminal segments very similar to those of *vexans*, fig. 102. Air tube scarcely more than two and one-half times as long as wide; pecten with apical two or three teeth markedly detached; ventral tuft short and beyond pecten. Lateral comb consisting of about 10 to 12 scales arranged in a regular single or double row. Anal segment, fig. 110B, almost completely ringed by dorsal plate, with only a narrow, V-shaped area of membrane between the ventral edges of the plate, bearing one or two ventral hair tufts anterior to apical mesal barred areas; gills tapering, longer than segment.

FEMALE.—Length of wing 5 mm. Color of beak, head, mesonotum, and legs similar to color of corresponding parts of *sticticus*. Each segment of dorsum of abdomen, fig. 117, with a median stripe of white scales, an apical band of white scales, and a nar-

row basal band of white scales, the center of the lateral area being dark scaled. In very light specimens the dorsum of the abdomen may be almost entirely white scaled. Wings predominantly dark scaled but with many of the anterior veins mostly pale scaled, especially toward the base.

MALE.—Similar in general to the female but with the abdomen darker; in dark extremes the first four segments may be almost entirely dark scaled. Male genitalia, fig. 149, similar in general to those of *sticticus*, with the following differences: apical lobe of basistyle more diagonal and longer; apical filament of claspette with a small but pronounced notch at the base of the apical filament.

We have only a single Illinois record of this species, from Savanna, June 19, 1942, in light trap (USPHS). The species is reported to be widespread and abundant in the Great Plains region. The larvae have been taken in temporary rain pools and marshes in Minnesota (Owen 1937).

20. *Aedes dupreei* (Coquillett)

LARVA.—Fig. 111. Head wide, with upper and lower hairs long, the upper hairs usually single, the lower ones double and situated almost directly anterior to upper ones; the species is unique in having the latero-dorsal hair of the frons branched. Eighth segment with a comb consisting of an even row of about six long teeth. Air tube only relatively long but narrow and tapering at apex, nearly four times as long as wide; hair tuft long, about six branched, situated before middle of siphon but beyond end of pecten; pecten consisting of an even row of few large teeth. Anal segment completely ringed by sclerotic shield; anal gills extremely long, over twice length of air tube, each gill containing a distinct trachea.

FEMALE.—Length of wing 2.5 mm. Beak and palps black, dorsum of head white scaled. Mesonotum with a wide silver stripe extending its entire length, the lateral area dark brown, abdomen entirely dark scaled. Legs almost entirely black scaled, except for the inner faces of the front and middle femora and all but the apices of the hind femora. Wings entirely dark scaled.

MALE.—Size and color as for female. Male genitalia, fig. 147: basistyle with projecting and sharp apical lobe that bears only isolated short setae; basal lobe somewhat

ovate, detached from basistyle, connected with it chiefly by membranous folds and by a short sclerotized bridge on which arises the macrochaeta. Claspette slender, its apical filament curved and saber shaped.

We have only one record of the species from Illinois, a series of four females from Ware, August 14, 1942, Ross & Mohr. The specimens were collected as pupae from a temporary rain pool in the post oak flats along the Mississippi River. The species is predominantly southern and southeastern in distribution, and the Illinois record is the one farthest north.

21. *Aedes fulvus pallens* E. S. Ross

LARVA.—Fig. 95. Head wide; upper head hairs long and single, lower ones long and double, situated as far anterior to the upper ones as half the distance between the upper hairs; between the lower hairs are a pair of very fine, branched hairs; preantennal hairs short and multiple. Thorax unique among the Illinois species in having the three lateral meso-thoracic tufts each 15 to 20 branched and relatively stout. Eighth segment with comb triangular, composed of about 30 small scales. Air tube short and tapering, stout, only twice as long as wide; ventral tuft large with about 14 filaments, situated ventrad of the pecten and considerably before its apex; pecten consisting of about 15 teeth, of which the 1 to 3 apical teeth are long, large, and well separated, the remainder small and forming a close row. Anal segment completely ringed with sclerotized dorsal shield; anal gills long and tapering, nearly twice as long as air tube.

FEMALE.—Length of wing 5.5 mm. Integument of almost entire body bright golden yellow except for a dark brown rectangle at each postero-lateral corner of the mesonotum, irregular dark brown areas at the ends of the abdominal tergites, and the almost black antennae. Body with conspicuous long slender hairs. Beak and palps yellow scaled, the extreme apex of both tipped with black scales. Mesonotum with scales of the ground color, very thin and scarcely wider than short setae. Abdomen with dorsum predominantly yellow scaled, the apex of each segment with a band of black scales. Legs yellow scaled, the knees and apical tarsal segments black scaled. Wings predominantly yellow scaled.

MALE.—Similar in size and color to female. Genitalia, fig. 143: basistyle with projecting and pointed apical lobe that continues basad to beyond the middle of the basistyle and ends in a low but definite shoulder; basal lobe completely detached from basistyle and joined to it by membranous folds, its macrochaeta appearing as a part of the basistyle proper rather than a part of the basal lobe; macrochaeta very long, flattened, widened at apex, and arising from a straplike internal thickening of the integument; basal lobe with slender setae. Claspette with base slender, its apical filament beyond the short neck abruptly enlarged to form a wide blade.

Our Illinois specimens belong to the subspecies *pallens*. It and its relatives have been treated in considerable detail by E. S. Ross (1943).

We have only two records for this species from Illinois, both from the southern quarter of the state (Ware and Mount Carmel). In addition, there is in the Chicago Natural History Museum a specimen from Hessville, Indiana, which is only a few miles from Chicago. This last specimen, which is a female, may have been carried to Hessville from Illinois or states farther south by rail or other transportation. The Mount Carmel specimen, a male collected in 1906, would seem to indicate that at least one colony existed in southern Illinois at that time. The Ware record consisted of four larvae collected August 14, 1942, Ross & Mohr, from a rain pool in the post oak flats; two of the larvae were reared, and males emerged. The species is primarily southeastern, and the Illinois records are apparently on the northwestern edge of its range.

The female from Hessville, Indiana, was recorded by Gerhard (1910) as *Aedes bimaculatus* (Coquillett), and the male from Mount Carmel, collected June 30, 1906, was recorded by Matheson (1930) as *Aedes cataphylla* Dyar.

22. *Aedes implacabilis* (Walker)

LARVA.—Fig. 106. Head relatively wide; upper and lower hairs very long, usually single, sometimes double, the lower hairs almost directly anterior to the upper hairs and without accessory hairs between them. Eighth segment with comb consisting of an arcuate row of five to seven teeth. Air tube

of moderate length, slightly more than three times as long as wide; lateral tuft very long and stout, usually with four filaments; pecten short, with about 15 teeth that usually form an even row in which the apical ones become slightly more separated. In some cases the apical one or two teeth may be definitely detached from the row. Anal segment completely circled by its sclerite; anal gills moderately long, tapering, and sharp.

FEMALE.—Length of wing 5 mm. Beak and palps black scaled. Dorsum of head and mesonotum tawny or golden scaled, the mesonotum frequently with a wide mesal band of reddish-brown scales. Abdomen with dorsum dark scaled, each segment with a basal band of white scales, the bands narrow at the base of the abdomen and becoming progressively larger toward apex. Legs with femora mostly pale scaled, tibiae pale with a mixture of dark scales, the tarsi predominantly dark scaled, without banding.

MALE.—Similar in size and color to female. Palps with a large apical brush. Genitalia, fig. 158: basistyle with a large ovate apical lobe, clothed with a cluster of fairly short setae, all pointing dorsad; basal lobe with ventral aspect forming a definite shelflike projection, the setae abundant and confined primarily to mesal aspect, macrochaeta single and moderately inconspicuous. Claspette with curved base, its filament narrow and angled, thickest at the angle.

Formerly known under the name *abseratus* Felt & Young, this species occurs in great numbers in a tamarack bog near Volo and in lesser numbers in neighboring bogs in the northeastern corner of the state. The larvae live in the sphagnum mat of shaded pools. In the bog at Volo such pools occur in the tamarack and poison sumac belt a few paces back from the open edge of the bog and contain no other mosquitoes except occasional colonies of *cinereus*.

Our Illinois records for *implacabilis* appear to be on the southern limit of the range of the species, which is northeastern in distribution. Only a single generation of adults emerges each year, in the late spring. The females are apparently crepuscular and do not bite to any considerable extent during daylight hours, even on days that are cloudy.

Illinois Records.—ANTIOCH: May 21, 1941, 2♂; April 23–30, 1942, 2♂, 1♀. VOLO: April 23, 1942, many larvae; April 26, 1942, 7♂, 2♀; May 3, 1942, 1♂; May 13, 1942, Ross,

Burks, & Mohr, 11 specimens, 1 ♀; May 16, 1942, many ♂ and ♀. WAUCONDA: emerged April 27, 1942, 1 ♂.

23. *Aedes punctor* (Kirby)

LARVA.—Head with the upper and lower hairs usually double. Eighth segment, air tube, and anal segment similar to those of *implacabilis*, differing chiefly in the comb. This has about 12 teeth forming a long irregular row (from Dyar).

ADULTS.—In size and general color indistinguishable from *implacabilis* adults. Male genitalia, fig. 156, differing in the following characters: apical lobe with longer and more abundant setae, which are curved dorsad; basal lobe much more massive, the sclerotized portion of the basistyle not extending out onto the lobe, the lobe curved and bearing abundant short setae over its entire surface and a very conspicuous macrochaeta at its basal corner; claspette with apical appendage short, curved, and narrowed at tip.

The only Illinois record of this species is a single male collected as a pupa in a tamarack bog pool at Volo; the adult emerged April 26, 1942. This specimen was collected in a large colony of *implacabilis*. Examination of hundreds of mosquito larvae and males from the locality failed to disclose a second specimen of *punctor*. The habits and distribution of *punctor* are almost identical with those of *implacabilis*.

10. *PSOROPHORA*

Robineau-Desvoidy

The females of this genus are fierce biters and the adults in many of the species are diurnal or nearly diurnal in habit. The life history of the genus is very similar to that of *Aedes*. The eggs are laid in damp ground cover and do not hatch until flooded. The larvae mature very rapidly. Larvae of two species are predaceous and feed on other mosquito larvae; larvae of other members of the genus are vegetarian and in the field are easily confused with those of *Aedes*. All species of the group breed intermittently throughout the summer. The larvae frequent temporary rain pools or flooded areas of many types. The adults of one or more species may appear in clouds soon after summer rains. All species hibernate in the egg stage.

The group is essentially southern. The range of the eight species known from Illinois does not extend far north of this state. Three other species of the genus occur within the territorial limits of the United States: *pygmaea* (Theobald) is recorded from southern Florida; *signipennis* (Coquillett) and *longipalpis* Roth occur in the central plains states and southwestward. The larvae are treated by Pratt (1946).

The species of this genus form three very distinct groups, which have been considered as subgenera. It is interesting to note that the female genitalia of all the Illinois species are practically identical.

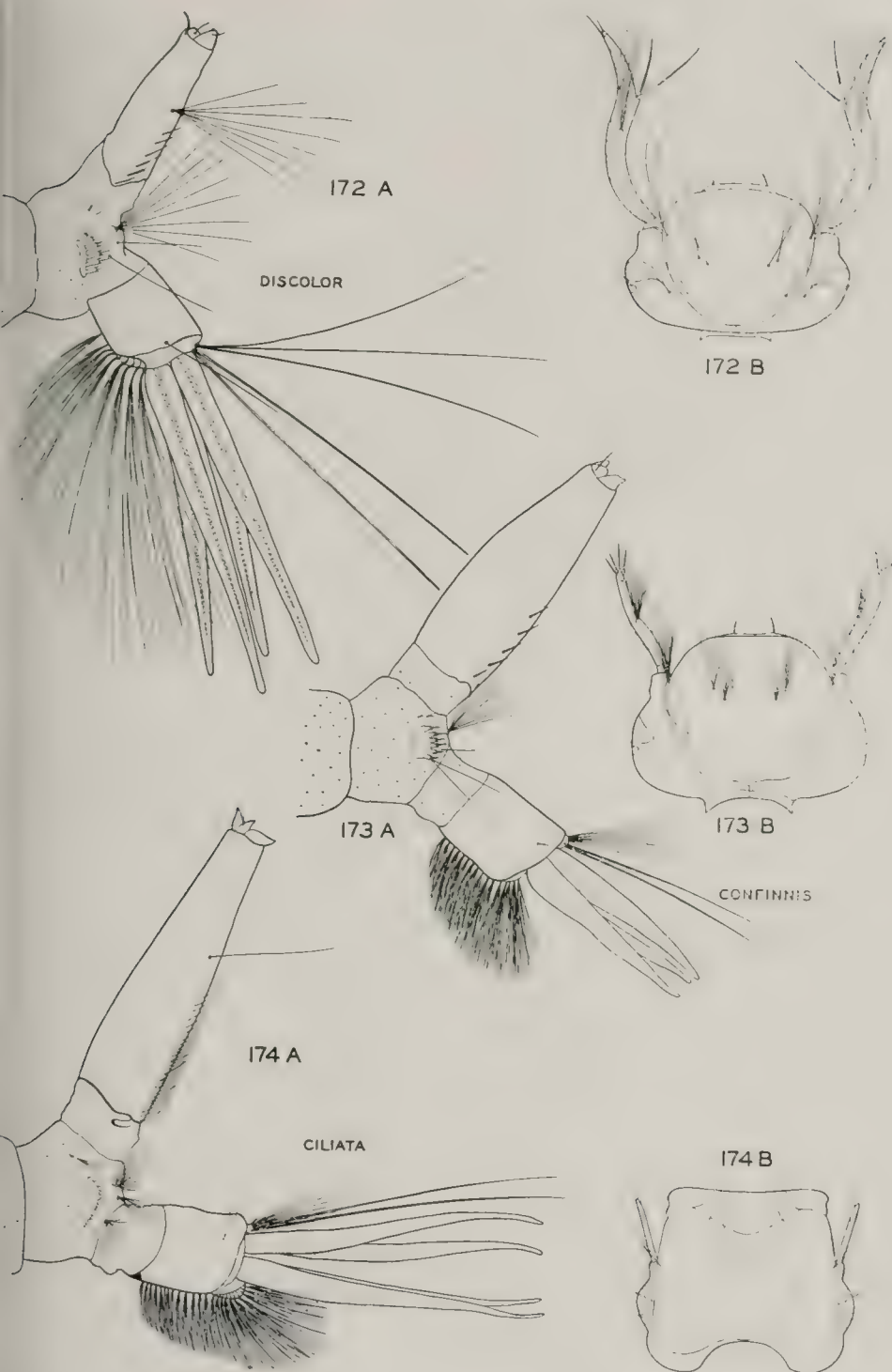
KEY TO SPECIES

LARVAE

1. Head quadrate, antennae short, slender, and without definite tufts, fig. 174; large predaceous larvae.....2
- Head oval, antennae long, stout, and with definite tufts, fig. 173; small to fairly large, bottom feeders.....3
2. Lateral hair of anal segment with two to four branches, separating at base of hair.....1. *ciliata*
- Lateral hair of anal segment single, or forked some distance from base.....2. *howardii*
3. Antennae very large and inflated, air tube small, fig. 172.....8. *discolor*
- Antennae not inflated and air tube large and swollen, fig. 173.....4
4. Upper and lower head hairs multiple.....7. *confinnis*
- Upper head hairs single or double, lower head hairs single to triple.....5
5. Upper and lower head hairs single.....3. *cyanescens*
- Upper and lower head hairs double or triple...4. *ferox*; 6. *varipes*; 5. *horrida*

FEMALES

1. Wing length over 6.5 mm., usually 7 to 8 mm.; mesonotum having a narrow mesal band of scales, flanked by a linear bare polished band on each side, fig. 26; hind femora each with a prominent tuft at apex, fig. 28.....2
- Wing length under 5 mm., usually 3.5 to 4.5 mm.; mesonotum with entire area scaled; hind femora sometimes bushy, fig. 30, but not with well-marked tufts.....3
2. Mesonotum with mesal band of scales yellow, hind tibiae and tarsi very bushy.....1. *ciliata*
- Mesonotum with mesal band of scales black, hind tibiae and tarsi pubescent but not unusually bushy.....2. *howardii*



Figs. 172-174.—*Psorophora* larvae: A, apex of abdomen, lateral aspect; B, dorsum of head. Mouth brushes are omitted from head drawings.

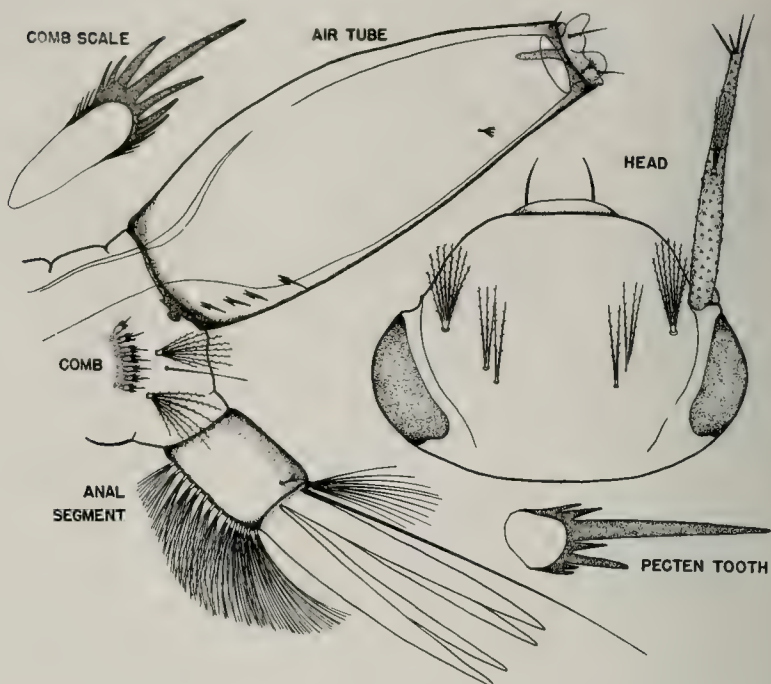


Fig. 175.—*Psorophora horrida*, larval parts. (After Roth.)

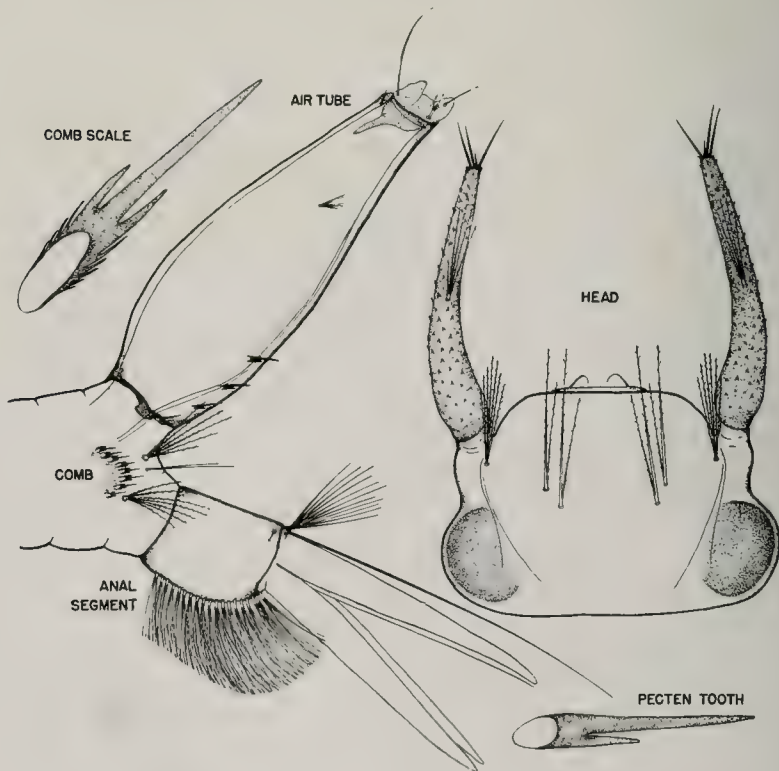


Fig. 176.—*Psorophora longipalpis*, larval parts. (After Roth.)

- 3. Hind tibiae and tarsi entirely purple; abdominal tergites purple, but with apical yellowish bands that are slightly broken on the meson....3. *cyanescens*
Hind tarsi either with all segments banded with white or with one or more segments all white, or dorsum of abdomen with only small lateral white spots, as in fig. 120.....4
- 4. Each tarsal segment with apex dark and base with a white band, as in fig. 28... ..5

- Each tarsal segment entirely dark or entirely light; a leg may be banded but with an alternation of entirely dark and entirely light segments; rarely one segment may be banded.....6
- 5. Wings mostly dark scaled but with a fairly even speckling of white scales; hind basitarsus nearly black, with two bright white bands, a narrow one at extreme base and a wider one at middle of segment.....7. *confinnis*

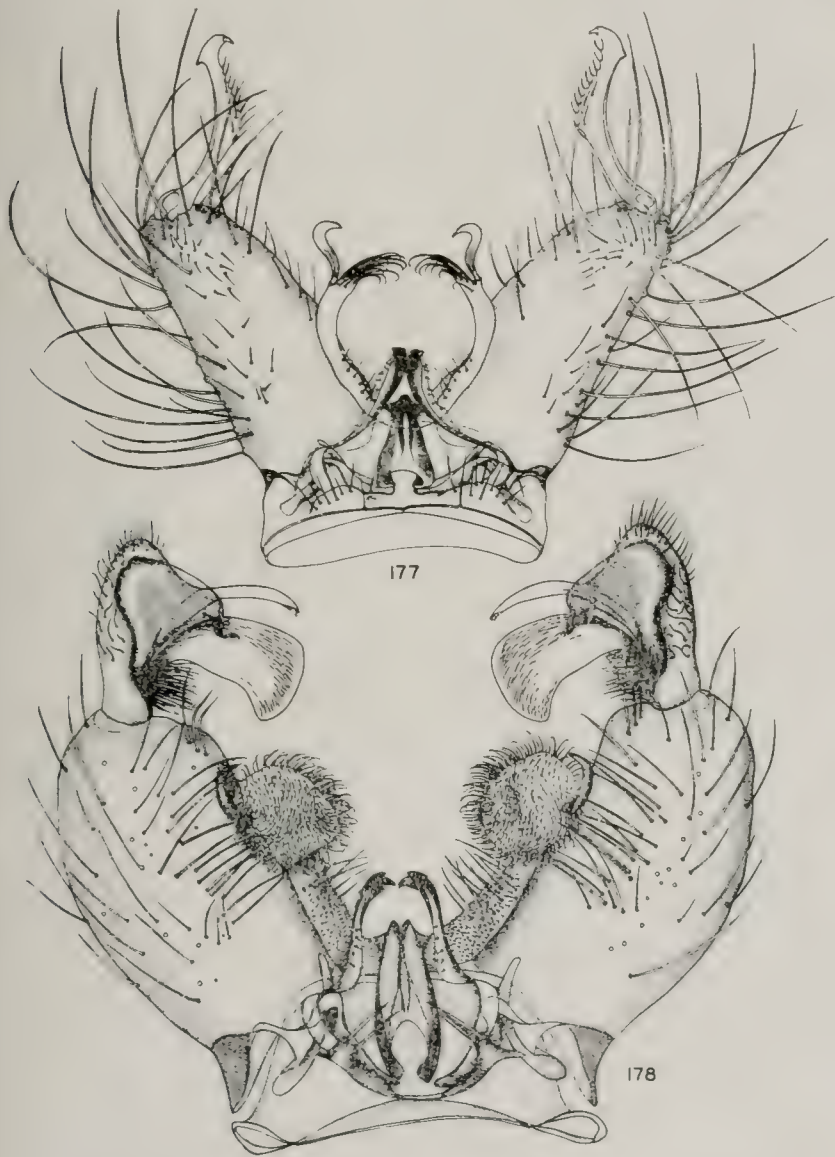


Fig. 177.—*Psorophora ciliata*, male genitalia. (After Matheson.)
Fig. 178.—*Psorophora howardii*, male genitalia. (After Matheson.)

- Wings with white scales grouped into definite lines or patches on some veins; hind basitarsus mostly white scaled but with dark scales intermingled uniformly along its entire length.....8. *discolor*
6. Mesonotum golden scaled over its entire area.....4. *ferox*
- Mesonotum with mesal half black scaled, lateral fourths white scaled, forming longitudinal bands.....7
7. Hind tarsi having next to last segment white, the remainder black.....6. *varipes*

Hind tarsi having last two or two and one-half segments white, the remainder black.....5. *horrida*

MALES

1. Dististyle with a large mesal lobe and a long mesal spurlike projection, fig. 179.....2. *howardii*
- Dististyle without mesal processes.....2
2. Dististyle with tip truncate and apical spur situated before apex, fig. 180.....6. *varipes*
- Dististyle with tip tapered and small, apical spur situated at end, fig. 179...3

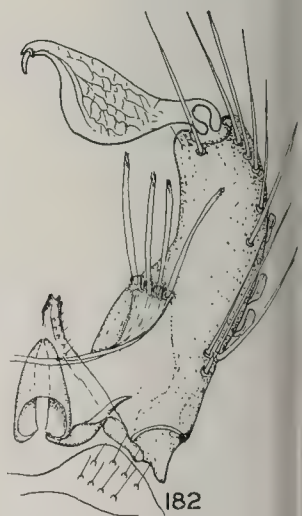
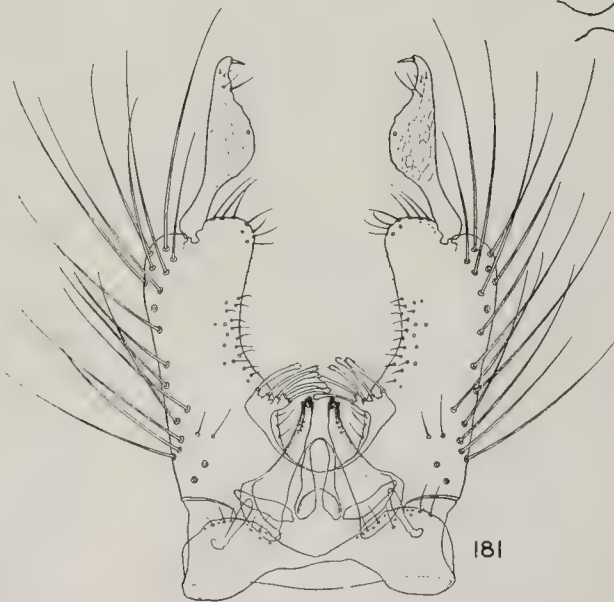
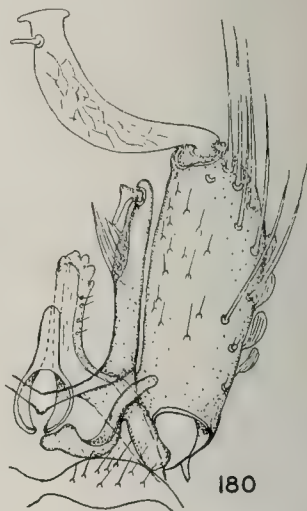


Fig. 179.—*Psorophora cyanescens*, male genitalia. (After Matheson.)

Fig. 180.—*Psorophora varipes*, male genitalia. (After Matheson.)

Fig. 181.—*Psorophora confinis*, male genitalia. (After Matheson.)

Fig. 182.—*Psorophora discolor*, male genitalia. (After Matheson.)

3. Dististyle narrow and sinuate, with a mesal row of bristles and a sharp subapical ventral tooth, fig. 177.1. *ciliata*
Dististyle expanded near middle, without mesal row of bristles and without ventral tooth, fig. 181.4
4. Apex of claspettes with a series of simple setae and two flattened contorted leaflets at lateral corner, fig. 183:1.4. *ferox*; 5. *horrida*
Apex of claspettes without contorted leaflets, at most with scales and thickened hairs, figs. 179, 182.5
5. Apex of claspettes with a dense series of hairs and scales, fig. 179.3. *cyaneascens*
Apex of claspettes with a series of only four to eight long, thickened hairs, fig. 181.6
6. Apex of claspettes with four or five thickened hairs, fig. 182.8. *discolor*
Apex of claspettes with five to eight thickened hairs, fig. 181.7. *confinnis*

SYNOPSIS OF SUBGENERA REPRESENTED
IN ILLINOIS

1. Adults with mesonotum having a pair of longitudinal, pale shining areas on each side of a narrow mesal band of scales; large species, gallinippers. Larvae predaceous, having quadrangular heads and small antennae without tufts, fig. 174.*Psorophora*
Adults with mesonotum having a uniform covering of scales; small to moderate size species. Larvae vegetarian, with ovate heads and long, tuft-bearing antennae, fig. 173.2
2. Palps of male not upturned at end; tarsal claws of female with large subapical

teeth; tibiae and tarsi purple except for a few segments of hind tarsi, which may be white.*Janthinosoma*
Palps of male upturned; claws of female without subapical teeth; tibiae with numerous white scales, tarsi having each segment banded with white at base, dark at apex.*Grabhamia*

Subgenus *Psorophora*
Robineau-Desvoidy

This subgenus includes two species, *ciliata* and *howardii*.

1. *Psorophora ciliata* (Fabricius)

LARVA.—Fig. 174. Head quadrate, with short slender antennae and only a few inconspicuous hairs. Eighth segment with the comb consisting of an arc of scales arranged along the edge of a slightly sclerotized crescent. Air tube long and moderately robust, tapering to apex, with pecten consisting of scales that are sclerotized at base and hair-like at apex. Anal gills very long.

FEMALE.—Length of wing 7 to 8 mm. Body integument yellowish brown, with the central part of the mesonotum dark brown to almost black; pubescence of many areas not sufficiently dense to obscure the integumental color. Beak and palps with erect, shaggy, dark or tawny scales, dorsum of head covered with white scales. Mesonotum, fig. 26, with a narrow center stripe of white scales, flanked on each side with a pol-

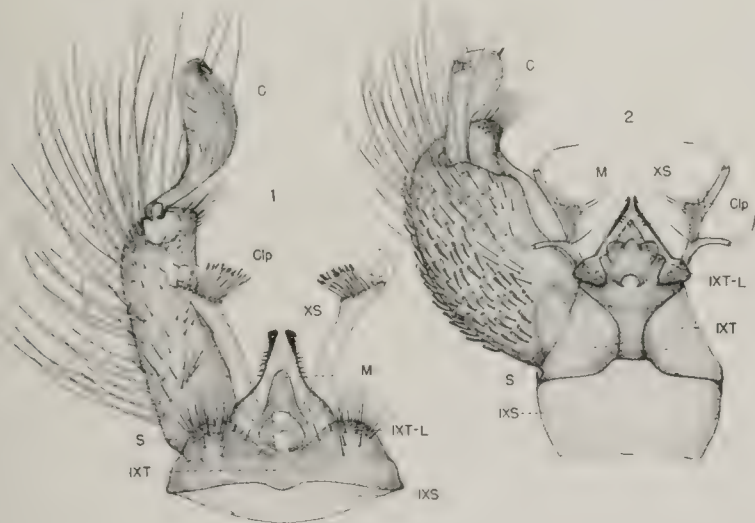


Fig. 183.—*Psorophora*, male genitalia. 1, *P. horrida*; 2, *P. longipalpis*. (After Roth.)

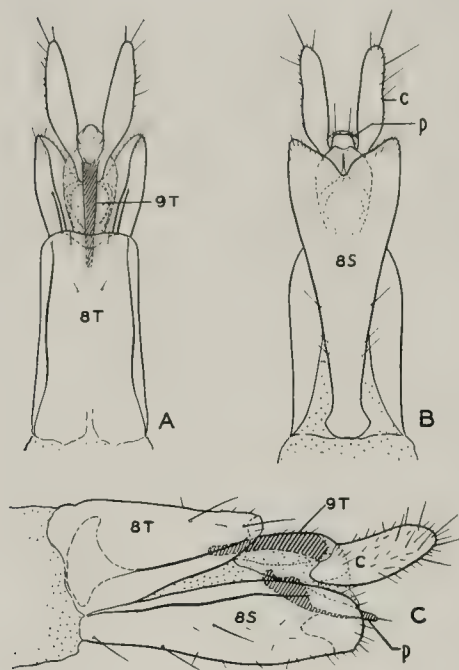


Fig. 184.—*Psorophora ciliata*, female genitalia. A, dorsal aspect; B, ventral aspect; C, lateral aspect. Abbreviations: c, cercus; p, postgenital plate; s, sternite; t, tergite.

ished pale stripe. Laterad of this is a narrow stripe of hairs and black scales and laterad of this is a large area clothed with white scales. Abdomen chiefly tawny or white scaled. Apical fifth of femora and all hind tibiae and tarsi very shaggy, with erect black scales; extreme base of each hind tibia and basal fourth or fifth of each tarsal segment with a band of appressed white scales. Front and middle tibiae and tarsi yellow, not shaggy. Wings dark scaled and usually inconspicuous.

MALE.—Similar in size, color, and general structure to female. Palps very long, much longer than beak, the apical three segments with a very large, extensive shaggy brush. Male genitalia, fig. 177: dististyle sinuate and narrow, bearing a mesal brush of bristles and a dorsal triangular projection near apex; claspettes long, free from basistyle, the apex of each with a row of thickened hairs and with a flattened sinuate leaflet on lateral corner.

This species is of unusual interest because it is one of the few whose larvae are predaceous on other mosquito larvae. The big

ciliata larvae, which breed in rain pools, usually with large numbers of *Aedes vexans* and with other species of *Psorophora*, move about among the other larvae and cause no commotion. When hungry, a *ciliata* larva simply makes a grab with its mouthparts and mouthbrushes for one of the smaller larvae (it seldom misses) and gradually maneuvers it so that, with the head or tail in its mouth, it can swallow its victim whole. In actions and habits in securing prey, *ciliata* larvae are almost the exact counterparts of the gars among the fish. Usually a full-grown *ciliata* larva will consume three or four other larvae per day. In spite of their large size, *ciliata* larvae mature as rapidly as the smaller species.

The *ciliata* females are vicious biters. After a blood meal, they are almost a terrifying sight, due to their large size and business-like appearance. They attack on cloudy days as well as during the evenings. The larvae, which breed in a wide variety of rain pools, are not frequently encountered, but in this state are generally associated with *Aedes vexans*.

Widely distributed from Central America through the central and eastern states to southeastern Canada, the species occurs generally over Illinois. It was recorded from Chicago by Gerhard (1910) and from Urbana by Matheson (1930).

Illinois Records.—Larvae, collected May 25 to September 8, and many males and females, collected May 29 to October 21, are from Algonquin, Beach, Beardstown, Bement, Bishop, Bridgewater, Cahokia (USPHS), Camp Grant (USPHS), Carbondale (USPHS), Carterville (USPHS), Cave-in-Rock, Champaign, Chebanse, Chicago, Crab Orchard Lake (USPHS), Downs, East St. Louis, Fountain Bluff, Gorham, Gratiot (USPHS), Grand Tower, Granite City (USPHS), Great Lakes Naval Training Station, Havana, Homer Park, Marion (USPHS), New Holland, Newton, Oregon, Pingree Grove, Rockford, Savanna (USPHS), Scott Field (USPHS), Thompson's Lake, Urbana, Ware, West Vienna, and Zion.

2. *Psorophora howardii* Coquillett

LARVA.—Almost identical with that of *ciliata*. The only reliable difference found to date is the single or split condition of the lateral hair of the anal segment (this hair is branched from base in *ciliata*).

FEMALE.—Similar to *ciliata* female in size, general color, and characteristics. It differs

chiefly in having the mesal stripe of the mesonotum composed of black scales, and in having the hind tibiae and tarsi yellow and only moderately spiny; identical to *ciliata* female in appearance of the front and middle legs.

MALE.—Similar to female in size and color. Palps very long, the apical brush represented by short scattered hairs. Genitalia, fig. 178, of striking appearance; claspette ending in an ovate hairy lobe; dististyle with a large, long flaplike mesal projection, the inner apical corner prolonged into a long slender beak.

This species has a wide distribution that embraces the Neotropical region and most of the southern part of the United States. It has been taken several times in southern Illinois and occasionally in central Illinois. The records for this state apparently represent the northern limit of the species range. The larvae have been reared from pools in woodlands and from pools in ruts through a pasture. In the latter case they occurred together with *Psorophora ciliata* and *Aedes vexans*. In southern Illinois they were taken, in company with *vexans* and *P. ferox*, in woodland pools in the post oak flats of the Mississippi River valley. The species has never been found abundantly in the state.

Illinois Records.—Larvae, collected June 9 to August 14, and adults, collected May 26 to September 16, are from Cahokia (USPHS), Carterville (USPHS), Chanute Field (USPHS), Crab Orchard Lake (USPHS), Goreville, Gorham, Grand Tower, New Athens, Scott Field (USPHS), Springfield, and Ware.

Subgenus *Janthinosoma* Arribáizaga

The species of this subgenus are conspicuous by the purple iridescent areas on the abdomen and legs, and the purplish cast on many parts of the body, such as the palps and wing scales.

Females of all the species in the subgenus are vicious biters.

3. *Psorophora cyanescens* (Coquillett)

LARVA.—(From Matheson 1944.) Head oval, upper and lower head hairs single and long, antennae stout and cylindrical, each with two- or three-haired tuft near middle. Eighth segment with lateral comb consisting of three or four stout scales on a small

sclerotized area. Air tube swollen, about three times as long as wide; pecten with three or four teeth. Anal gills slender, very long and pointed.

FEMALE.—Length of wing 4.5 mm. Beak and palps black or purplish. Integument of head and thorax dull black. Dorsum of head and entire mesonotum covered with whitish scales. Dorsum of abdomen with segments purple scaled except for an apical band of white scales, the band of the apical segments interrupted on the meson. Legs with femora almost entirely yellow; extreme apices of femora and all the tibiae and tarsi purple; extreme tips of femora each with a small whitish knee spot. Legs purple scaled, the scales inconspicuous.

MALE.—Genitalia as in fig. 179: dististyle sinuate, expanded at middle; claspettes free from basistyle only near apex; apical margin of claspettes with a dense row of hair and scales and with a long curved spine on the lateral corner.

Adults of this species have been taken in numbers in southern Illinois but to date we have found no larvae. The adults are very unusual in many of their habits. They attack during the day and seem to prefer bright sunlight. Extremely rapid fliers, they make a high-pitched sound somewhat resembling that of a humming bird. They are wary and circle a prospective victim before alighting. We found it necessary to let them get a good start at biting before we could bottle them with certainty. On one occasion Dr. Carl O. Mohr and I encountered a flight of adults at West Vienna. When we stepped into the bright sun, the *cyanescens* females attacked quite readily. When we retired into nearby shade, we were not molested. We repeated this action several times and always with the same results. A single female of this species makes so much noise that it can be heard approaching for several yards.

As in other members of the genus, the larvae are reported to breed in rain pools of various types.

Like *howardii*, this species extends its range from the Neotropical region into the southern and central states. It has been recorded from states as far north as Oklahoma, Kansas, and Illinois.

Illinois Records.—Adults, collected May 21 to September 15, are from Carterville (USPHS), Crab Orchard Lake (USPHS), East St. Louis, French Village (USPHS), Granite City (USPHS),

Marion (USPHS), New Holland, Savanna (USPHS), Scott Field (USPHS), Ware, and West Vienna.

4. *Psorophora ferox* (Humboldt)

LARVA.—Head ovate, antennae elongate, with a multiple tuft near middle, upper and lower head hairs double. Eighth segment with a comb of six or seven scales arranged along the edge of an indistinct sclerite. Air tube stout, expanded, about three times as long as wide; pecten of three or four stout teeth.

FEMALE.—Length of wing 4.5 to 5.0 mm. Integument of head yellowish brown, mesonotum almost black. Beak and palps covered with purplish scales. Dorsum of head and pronotum with a uniform but not close covering of whitish or yellowish scales. Dorsum of abdomen purple with lateral white spots visible on segments 4 to 7. Legs with femora yellow, the apical and upper areas purple; tibiae and tarsi purple except for the last two or two and one-half segments of the hind tarsi, which are white; tip of femora with small white knee spots. Wings purplish-brown scaled.

MALE.—Similar to female in size and color. Palps elongate, with only a sparse brush at apex. Male genitalia with dististyle considerably expanded and leaflike, claspettes with a long base, entirely free from basistyle, and with their apices ornamented with a row of setae and each having two or three contorted leaflets on lateral corner; very similar to genitalia of *horrida* (fig. 183:1). To date, no very satisfactory characters have been found to separate the two species on genitalia. The color markings given in the key to females are much more trustworthy.

Common in many parts of Illinois, this species is frequently a real pest. The females are fierce biters and attack readily during the day in shady situations. The larvae breed most abundantly in flood pools, and in stream or river valleys. The first generation of adults emerges early in the season, usually about the middle of May or shortly afterward, and successive generations are on the wing through the summer and well into September.

This species has a wide range from southeastern Canada through the eastern United States into the Neotropical region. In Illi-

nois the species is encountered in much greater abundance in the southern half of the state than northward.

Illinois Records.—Larvae were collected at Karnak, April 29, 1941. Many males and females, collected May 13 to October 14, are from Benson, Cahokia (USPHS), Carbondale (USPHS), Carterville (USPHS), Champaign, Crab Orchard Lake (USPHS), East St. Louis, Elsah, Fort Chartres State Park, Glencoe, Gorham, Gossett, Grand Tower, Grantsburg, Grayville, Havana, Herod, Homer, Karnak, La Rue, Lawrenceville (USPHS), Mascoutah, Momence, Oakwood, Patton, Quincy, St. Jacob, Scott Field (USPHS), Springfield, Urbana, Utica, Vienna, Ware, West Vienna, White Heath, and Wolf Lake.

5. *Psorophora horrida* (Dyar & Knab)

LARVA.—Fig. 175. Very similar to the larvae of *ferox* and *varipes*. To date, reliable and tested characters have not been found to insure correct identification of the larvae of this group of species.

FEMALE.—Length of wing 4.5 mm. Head and thorax nearly black. Palps and beak purple scaled. Dorsum of head white scaled. Mesonotum with mesal third black scaled, lateral third white scaled, these areas forming definite longitudinal bands. Dorsum of abdomen purple scaled with small white patches on some or all of the segments. Femora with basal portions mostly yellow; the apical and dorsal areas are black, and the extreme tip (knee) is white; tibiae and tarsi purple with the exception of the last two segments of the hind tarsi, which are white. Wings purple scaled.

MALE.—Similar in size, color, and general structure to female. Genitalia, fig. 183:1, with dististyle swollen and leaflike; claspettes each with a long stalk, which is free from basistyle, and with apex bearing a row of setae and two contorted leaflets at the lateral corner.

A species of very similar coloration, *longipalpis* Roth (1945a), is distinguished in lacking the white knee spot and also in details of the male genitalia, fig. 183:2. The larva of *longipalpis* differs from that of *horrida* chiefly in details of the chaetotaxy, fig. 176. A species that occurs along the eastern portion of the great plains, *longipalpis* may eventually be found in Illinois.

Very similar in habits and distribution to *ferox*, *horrida* breeds in immense numbers in bottomland pools. It has been taken

abundantly in the southern half of the state and less abundantly in the northern half. The females are vicious biters that attack readily in the daytime.

Illinois Records.—Adults, collected May 4 to September 24, are from Camp Grant (USPHS), East St. Louis, Elizabethtown, Fort Chartres State Park, Grantsburg, Havana, Joetta, Kappa, Karnak, La Rue, Mascoutah, Momence, Mounds, Mount Vernon (USPHS), Oak Park, Patton, Pere Marquette State Park, Quincy, Rockford, St. Jacob, Savanna, Scott Field (USPHS), Seymour, Starved Rock State Park, Urbana, Utica, Warsaw, Wedron, White Heath, White Pines Forest State Park, and Whitesville.

6. *Psorophora varipes* (Coquillett)

LARVA.—Practically identical with the larvae of *ferox* and *horrida*. To date satisfactory characters have not been found to identify these forms.

FEMALE.—Length of wing 4.5 mm. Integument of head and thorax black. Beak and palps purple scaled. Dorsum of head white scaled. Mesonotum with mesal half black scaled, lateral fourth white scaled and forming a conspicuous stripe. Abdomen purple with lateral white spots as in *ferox*. Legs with base of femora yellow, apical and dorsal portions purple; tibiae and tarsi entirely purple with the exception of the fourth tarsal segment of the hind tarsi, which is white; apices of femora each with a conspicuous knee spot.

MALE.—Size, color, and general structure as for female. Male genitalia, fig. 180, with dististyle expanded, broad to apex, apical spine situated just before the tip; claspettes long, free from basistyle, the apex with a row of spines and a foot-shaped leaflet on lateral corner.

This southern species has been taken only in the southern third of Illinois. At times it is abundant in the cypress bottoms, and the larvae probably breed in the summer rain pools of this area. It is a vicious biter and is on the wing as early as the middle of May. No larvae have been taken in our recent survey; habits of the larvae are recorded as being similar to those of other species in the genus.

Illinois Records.—Adults, collected April 30 to August 15, are from Cache, Duck Pond Hill, Grand Tower, Grantsburg, Karnak, La Rue, Lawrenceville (USPHS), Patton, Scott Field (USPHS), and Ware.

Subgenus *Grabhamia* Theobald

The members of this group are non-metallic in color and drab in appearance. The scales of the occiput and mesonotum are usually small and well separated. Another characteristic of the subgenus is the mixture of white scales and dark scales on the wing; in some species this mixture develops into a definite pattern.

7. *Psorophora confinnis* (Arribáizaga)

LARVA.—Fig. 173. Head ovate, wider than long, with long antennae having a multiple tuft near middle; upper and lower head hairs multiple, usually with five or six branches. Eighth segment with comb consisting of about six scales arranged in a crescent. Air tube slightly swollen near middle, tapering near apex; pecten consisting of about four teeth. Anal gills of moderate length, pointed.

FEMALE.—Length of wing 4.5 mm. Palps dark-brown scaled with tip white scaled; beak with central half tawny scaled, base brown scaled and apex black scaled. Integument of head and thorax sooty dark brown, nearly black. Dorsum of head tawny scaled. Mesonotum with a mixture of brown and white scales. Dorsum of abdomen dark-brown scaled with apical patches of white scales; on segments 2 and 3, these form a continuous band across the segment and on the segments beyond that they form a pair of lateral areas usually fairly well separated on the meson. Femora predominantly dark-brown scaled and having irregular white scales scattered throughout, with a definite band of white scales just before the apex, fig. 31, and with a prominent small knee spot at apex; tibiae dark-brown scaled with patches of white scales that make a series of dots running down the full length of the segment; tarsi of all legs nearly black, the basitarsus with a very narrow white ring at base and a definite tawny ring at middle, the remaining segments with the basal third or half white. Wings with a fairly even mixture of white scales and dark scales distributed so that no spots or bands result.

MALE.—Similar in size, color, and general structure to female. Palps long, the apical two segments and part of the preceding with a long, extensive, and conspicuous brush. Male genitalia, fig. 181: dististyle

expanded and leaflike in middle; claspettes each with short stem and solidly fused to the basistyle; apices of claspettes each with a row of five to eight thickened hairs.

The larvae of this species breed in temporary rain pools of pastures, farm yards, and other more or less open situations. The females bite fiercely.

Breeding in immense numbers, this species is a scourge in the flooded rice fields of Arkansas and other southern states. In Illinois it is common only in the southern part of the state. It has been taken in small numbers as far north as Chicago. Until recently the name *columbiae* was generally used for this species, and under this name it was recorded in Illinois by Matheson (1930). The species is widely distributed from about the latitude of central Illinois south into the Neotropical region.

Illinois Records.—Larvae, collected May 26 to September 16, and many males and females, collected May 27 to October 11, are from Beardstown, Belleville (USPHS), Benson, Cahokia (USPHS), Cairo (USPHS), Carbondale (USPHS), Carterville (USPHS), Champaign, Crab Orchard Lake (USPHS), East St. Louis, Elizabethtown, French Village (USPHS), Grafton (USPHS), Granite City (USPHS), Grand Tower, Havana, Johnston City (USPHS), Marion (USPHS), Mount Vernon (USPHS), Oak Park, Sandoval, Scott Field (USPHS), Springfield, Vienna, Ware, and West Vienna.

8. *Psorophora discolor* (Coquillett)

LARVA.—Fig. 172. Head broad; antennae very long, thickened, with a multiple dorsal tuft near middle and with two stout spines on venter about two-thirds distance from base; preantennal tuft double and long; upper and lower head hairs single. Eighth segment with a crescentic comb of six scales united by a small sclerotized area. Air tube very short, about as long as width of seventh segment, the tube itself about three times as long as wide, with a pecten of about four or five long scales and with a multiple ventral tuft that is as long as the tube. Anal gills very long, with a trachea extending the full length of each.

FEMALE.—Length of wing 3.5 mm. Integument of head and thorax dull, dark gray-brown. Beak with middle half pale scaled, base and apex brown; palps brown with a few white scales at tip. Head with a scattering of brown scales and narrow sil-

very scales. Mesonotum with a mixture of brown scales and silvery gray scales, all of which are small and well separated, giving a stippled effect. Dorsum of abdomen predominantly white scaled, with an irregular mixture of brown scales, the scales normal in size and overlapping. Femora with a mixture of white and brown scales, with a definite preapical band of white scales, and a white knee spot, the area between the preapical band and the knee spot predominantly brown; tibiae chiefly white scaled, with an intermingling of brown scales, especially toward tips; basitarsus white scaled with brown scales predominant toward tip; remaining tarsal segments with basal half white scaled, apex brown to black. Wings predominantly white scaled, with an intermingling of brown scales that form a long irregular blotch near the middle of Costa and many short lines scattered throughout the rest of the wing, giving it an irregular mottled appearance.

MALE.—Similar in size, color, and general structure to female. Palps very long, with an extensive conspicuous brush. Male genitalia, fig. 182, almost exactly as in *confinnis* but usually with only four setae at the apex of each claspette.

Adults of *discolor* have frequently been confused with those of *signipennis* (Coquillett), a more western species. The *signipennis* adults may be distinguished by the barlike costal markings in the wings, which are as definite as those in fig. 66.

Occurring through most of the South, this species has been taken westward to Oklahoma and Texas. In Illinois it has been taken chiefly in the southern fourth of the state. It is recorded as biting man, but in Illinois it is not numerous enough to be a pest. The larvae breed in rain pools. The largest colony of larvae we encountered in our Illinois survey was in a weed-choked roadside ditch. The general area was cleared and open, but the ditch was overgrown and heavily shaded with weeds. The larvae were wary and sparse, and some patience was required to gather a series, one larva at a time.

Illinois Records.—Larvae, collected June 8 to August 3, and adults, collected May 29 to September 27, are from Cahokia (USPHS), Carterville (USPHS), Crab Orchard Lake (USPHS), East St. Louis, Fort Massac State Park, Grafton (USPHS), Granite City (USPHS), Herrin (USPHS), Marion, Mount Carmel, Mount Vernon, Scott Field, Seneca (USPHS), and Ware.

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The Leafhoppers, or Cicadellidae, of Illinois

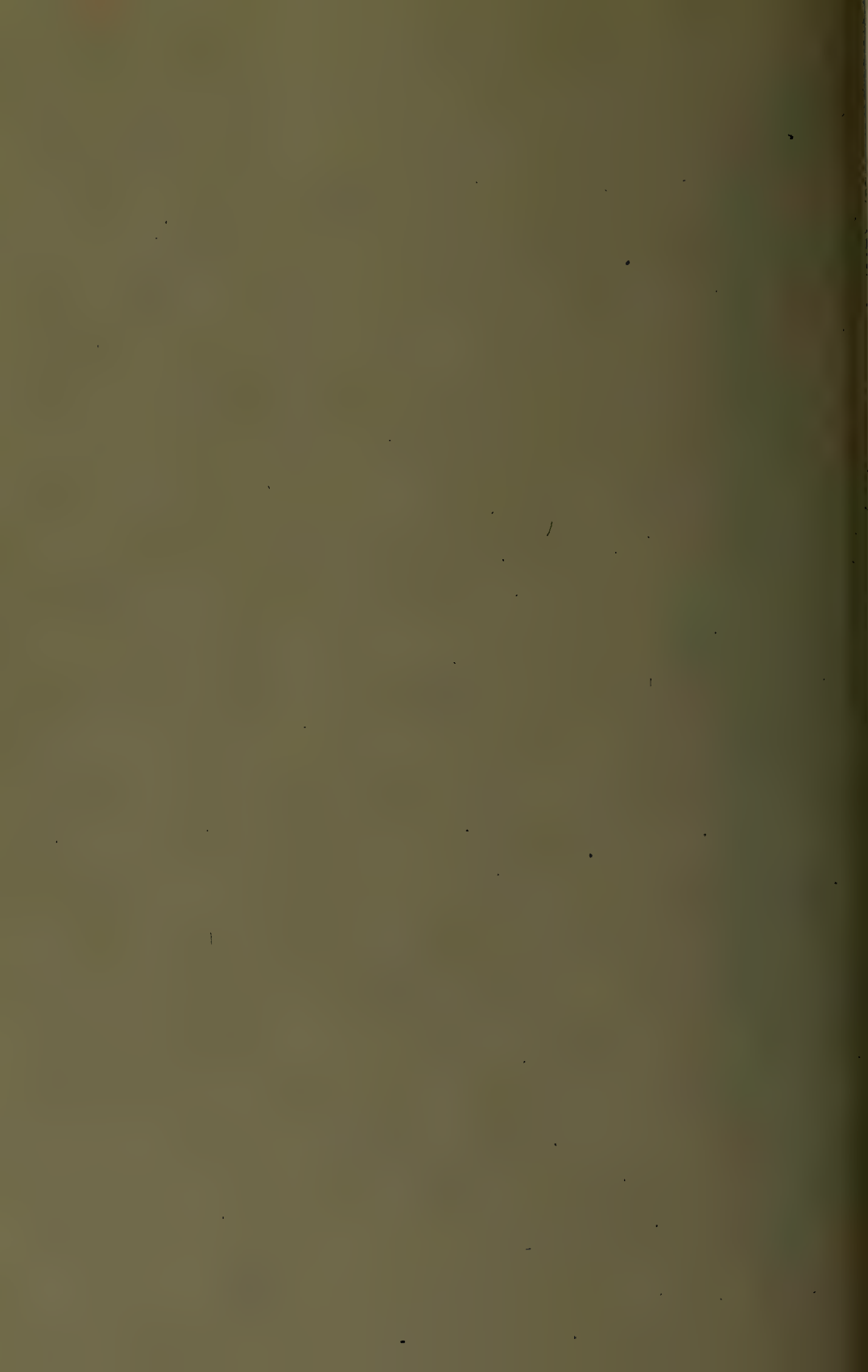
(Eurymelinae-Balcluthinae)

D. M. DELONG



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Volume 24

BULLETIN

Article 2

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D. M. DELONG



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This paper is a contribution from the Section of Faunistic Surveys and Insect Identification.

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FOREWORD

IN 1934 a project was organized to investigate the Cicadellidae, or leafhoppers, of Illinois and to prepare a comprehensive report on the fauna of the state. Dr. D. M. DeLong, Ohio State University, Columbus, Ohio, very kindly accepted the post as project leader to direct the field work, identify the material, and write the final report. Accordingly, Dr. DeLong was employed by the Illinois Natural History Survey as Assistant Entomologist during the summers of 1934, 1935, 1936, and 1938, and as Research Entomologist for shorter periods in 1941 and 1945.

In general pattern, the field program for the leafhopper study followed that for the Natural History Survey's study of other groups, such as the Miridae. From 1934 through 1936 collecting trips, to various parts of the state, were planned to include as many diverse ecological types as possible. Areas of natural vegetation provided the most extensive faunal possibilities. Many of these exist throughout Illinois in the state parks and forests, in national forests, along railroad rights-of-way, and in small scattered areas that are not readily arable. Altogether, several hundred thousand leafhoppers were collected, of which over 30,000 were mounted for study and added to the 5,000 specimens already in the Survey collection. Because of the size of the group it was decided to exclude from the present report the large subfamily Cicadellinae (formerly Typhlocybinae).

During the period of the 1930's, the taxonomic status of many leafhopper genera was in a state of flux, because of the increasing employment of genitalic characters for specific identification. In consideration of this, the preparation of the final leafhopper manuscript was postponed for several years pending studies of various large genera such as *Gypona* and *Idiocerus*.

A large portion of the identifications and preparation of the manuscript was done by

Dr. DeLong at Columbus, Ohio, and we are very grateful to him for contributing so much of his own time to this project. We also wish to express our gratitude to Dr. Herbert Osborn of Ohio State University, Dr. P. W. Oman and Dr. H. E. Dorst of the U. S. Department of Agriculture, and Dr. R. A. Beamer of the University of Kansas for the loan of drawings or cuts, for permission to use illustrative material, or for other assistance; and to Miss Ruth V. Hershberger of Ohio State University for making many drawings of diagnostic parts.

Several members of our staff in the Section of Faunistic Surveys and Insect Identification have contributed materially to the project. All members of the section have assisted with the field program. The original total views of leafhoppers are the work of Dr. Carl O. Mohr, Associate Entomologist and Artist. Mrs. Elizabeth N. Maxwell, Artist, has contributed many drawings of diagnostic parts used in the subfamily and generic keys, and she and the Survey draftsman, Mr. James W. Curfman, have assembled, numbered, and lettered the plates. Miss Phyllis A. Beaver, Laboratory Assistant, assembled and summarized the Illinois records in our files, and Dr. B. D. Burks, Associate Taxonomist, prepared the bibliography. Adapting the manuscript to current Survey practices, modifying the keys to emphasize as much as possible characters that could be illustrated, and integrating in our office the many parts of the manuscript represent the painstaking and effectual work of Dr. Milton W. Sander-son, Associate Taxonomist. The index to scientific names was made by Mrs. Leonora K. Gloyd, Laboratory Assistant. We have enjoyed throughout the help and cooperation of the Survey Technical Editor, Mr. James S. Ayars.

HERBERT H. ROSS,
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An area of marsh grasses in an oak woods near Amboy, Illinois. The diversity of plant species in this spot makes it an ideal collecting ground for leafhoppers. Distinctive forms of trees, shrubs, herbs, or grasses all occur within this small area.

The Leafhoppers, or Cicadellidae, of Illinois

(Eurymelinae-Balcluthinae)

D. M. DeLONG

THE leafhoppers, or Cicadellidae, constitute one of the largest families of insects in North America and also in the entire world, rivaling in number of species such groups as the rove beetles, or Staphylinidae, the hymenopterous family Ichneumonidae, and the weevil family Curculionidae. When complete, the Illinois list of leafhoppers will probably be close to 700 species. This report deals with about half of the Illinois leafhopper species, comprising 16 subfamilies. The other half belongs to the large subfamily Cicadellinae, which is not treated in this report except for a key to the genera.

Three hundred thirty species of the subfamilies here treated are recorded from Illinois. Additional species whose range indicates that they might be found in the state with subsequent collecting have been added to the keys for the purpose of giving a more thorough understanding of the Illinois species.

Many leafhopper species are economically important, either inflicting direct damage to crops, or transmitting plant diseases. These species are difficult to differentiate from many forms considered to be of little or no economic importance. One of the principal aims of this report is to set forth keys and illustrations for their identification.

BIOLOGY

Some species of leafhoppers pass the winter in the egg stage and others in the adult stage. Overwintering eggs, present in plant tissues, hatch somewhat late in the

spring, usually in May or June, and the nymphs feed on the new, tender leaves. Species of leafhoppers that pass the winter as adults normally come out of their hibernation quarters during the first warm days of spring and begin to lay eggs as soon as the leaves of their host are fully developed. These eggs hatch in about 10 days. There are five nymphal instars in the life cycle before the adult stage, which usually requires from 12 to 30 days, depending upon the species and the climatic conditions. As a rule, leafhoppers have one or two generations per year but, where completion of the cycle is rapid and cropping conditions or sequence of plants furnishes an abundance of food, other generations may be produced. *Empoasca fabae*, the potato leafhopper, and certain species of *Erythroneura* produce probably the largest number of broods.

About 10 years ago, the writer (1938a) reported in some detail upon the biology of the potato leafhopper, which might serve as a specific example for the discussion of various biologic phenomena and developmental stages. The adults of this species may mate within 24 hours after emergence; the preoviposition period may be as short as 3 days and it averages less than 6 days. The eggs are inserted singly into tender stems of leaf veins. The number of eggs produced varies considerably in this species. In general, the females lay eggs for a month or more and produce about 75 eggs in this period. In 1926 one second generation female produced 226 eggs in 47 days, an average of 4.8 eggs per day. The highest daily egg-laying record was 8 eggs in a 24-hour period. In the same year, 51 females

produced 2,327 eggs. One female deposited 195 eggs over a period of 92 days and another 216 eggs in 85 days. The average incubation period for 1,964 observations during a single season was approximately 10 days. The minimum incubation period observed was 7 days and the maximum 19 days. There seems to be a definite correlation with temperature conditions.

In the process of hatching, the nymph pushes itself through the egg membrane and the plant epidermis; at this time the legs extend tightly along the ventral side of the body to the tip of the abdomen. By a backward and forward swaying motion of the body the legs are freed; then the tip of the body is soon freed, and the nymph becomes active upon the plant. The time required for nymphal development varies from a minimum of 10 to a maximum of 22 days, depending upon temperature. The average number of days from egg to adult is usually 12 to 14 in a normal season.

Four distinct broods of the potato leafhopper occur, the fourth giving rise to only a small number of individuals in the northern states.

Hibernation.—Several common species of leafhoppers are known to pass the winter in hibernation as adults in leaf mold and under the loose bark of trees. Species of *Agallia*, *Macrostelus*, *Balclutha*, *Polyamia*, *Laevicephalus*, *Paraphlepsius*, *Deltoccephalus*, *Exitanus*, and especially species of *Erythroneura* and *Empoasca* have been collected in hibernation and have been found coming out of hibernation in early spring. A large number of species of *Erythroneura* have been described from hibernating specimens only and nothing is known of their food plant and their relationship to plant associations.

Field observations and hibernation experimentation indicate that each spring *Empoasca fabae* migrates from the southern states into the northern states and does not normally pass the winter out of doors in Illinois or states of similar latitude.

Feeding Habits.—Insofar as known, all leafhoppers are plant feeders that, in feeding, puncture the tender plant tissues by piercing-sucking mouthparts. Such feeding studies as have been made indicate that most species feed upon the mesophyll and cause a white stippled appearance upon the foliage. *Empoasca fabae* and probably other species make exploratory punctures deep into the

tissue, causing the mechanical plugging of xylem and phloem vessels.

Not infrequently leafhoppers bite humans. Biting is common in certain leafhoppers attracted to lights, especially in little green species of the genus *Empoasca*. Their bite is sharp, but usually produces itching of only short duration.

ECOLOGICAL RELATIONSHIPS

The leafhoppers are usually restricted to definite plant species or genera. The plants are in turn limited in their distribution to definite habitats due largely to climatic and edaphic conditions. As a result a species of leafhopper or a group of species can usually be associated with a definite habitat or plant association. The leafhoppers, however, are not invariably found wherever their hosts occur. Some species of leafhoppers seem to be distributed throughout the full range of their food plant, whereas others seem to be restricted by climatic factors to an area within the food plant range. This latter condition is exemplified by the species of *Idiocerus* occurring on *Crataegus*, which do not occur, apparently, throughout the entire range of their respective plant hosts.

The state of Illinois, with its long north and south axis and varied conditions, exhibits a variety of plant associations which afford interesting collecting and a variety of interesting northern, southern, and western species of leafhoppers. A large percentage of leafhopper species feed upon grasses, sedges, or herbaceous plants, and the varieties of prairies, sandplains, meadows, and marshes furnish excellent opportunities for obtaining many interesting records.

Sand Habitats.—The sand prairies along the upper Mississippi River at Fulton, Hanover, and Thomson, fig. 1, which are unique in the plant association of the state, contain species of leafhoppers that apparently do not occur elsewhere in Illinois. Such species as *Flexamia grammica*, which occurs on the large coarse sand reed (*Calamovilfa longifolia*), and *Polyamia herbida*, which is found on the short matted grasses of the same habitat, have not been discovered elsewhere in the state. In the same habitat occur *Flexamia areolata* and *abbreviata*, *Polyamia rossi*, *Hebecephalus cruciatus*, *Paraphlepsius solidaginis*, and *Chlorotettix brevidus* in addition to several more common species



Fig. 1.—Sand prairie at Thomson, Illinois. Many unusual leafhoppers of the genera *Flexamia* and *Polyamia* are found in such situations.

In the sand prairie at St. Anne in the eastern portion of the state south of Chicago, we also find *Flexamia areolata*, and in addition *Flexamia bidentata*, *Chlorotettix borealis*, and *Paraphlepsius maculosus*. On scrub oak in the same area occur *Eutettix pictus* and *Penthimia americana*. On the grasses of a different type of prairie, at Des Plaines,

where wild rose is a prominent plant species, *Laevicephalus pravus* occurs. The high well-drained prairie at Decatur contains two interesting western species of leafhopper, the "long-nosed" *Dorycephalus platyrhynchus* and the small striped *Commellus comma*. On the hot barren denuded soil in the Mississippi River valley at Alton are



Fig. 2.—Swale and sand dunes along the edge of Lake Michigan near Zion, Illinois. Many host plants of northern leafhopper species are restricted in Illinois to this area.



Fig. 3.—Mats of bearberry, *Arctostaphylos uva-ursi*, on the sand ridges along Lake Michigan, near Zion, Illinois. This plant is the sole host for *Texananus cumulatus*.

small patches of sparse short grasses upon which was found *Athysanella balli*.

At Zion, Illinois, the sand prairie along the shore of Lake Michigan presents still another habitat type, fig. 2. Here the short grasses are mixed with prostrate mats of bearberry (*Arctostaphylos uva-ursi*) and ground juniper (*Juniperus horizontalis*).

On the grasses are such species as *Paraphlepsius turpiculus*, *Dorydiella kansana*, *Graminella mohri*, and *Graminella oquaka*. *Dorydiella kansana* has been taken from *Scleria verticellata* in the *Eleocharis obtusa* association, and *Graminella mohri* occurs on *Andropogon furcatus*. The mats of bearberry, fig. 3, support large populations of



Fig. 4.—In the old Lake Michigan basin south and west of Chicago, near Oak Lawn and Evergreen Park, are many remnants of prairies such as this. They support a leafhopper fauna of unusual interest.

Texananus cumulatus, which apparently is limited in Illinois to this area alone.

The old Lake Michigan basin, south and west of the city of Chicago, presents a series of dry and wet prairies, fig. 4, which vary considerably in their plant composition. Certain portions of this area near Evergreen Park and Oak Lawn have been collected extensively with interesting results. At Evergreen Park on a heavy mat of prairie grasses *Flexamia rubranura*, *picta*, *inflata*, *Laevicephalus unicoloratus*, and *Remadosus magnus* were taken. A typical prairie species, *Mesamia nigradorsum*, was found abundantly on wild sunflower throughout this prairie. On a moister portion of the prairie, species collected included *Graminella aureovittata*, *Chlorotettix rugicollis*, *spatulatus*, *fallax*, and *Dorydiella kansana*, which seem entirely out of their range, since most of them except *Chlorotettix spatulatus* and *Dorydiella kansana* have been described from and occur either in Florida or along the Gulf or South Atlantic Coast. On small areas in this same Oak Lawn region where the water table is high and mats of fine *Eleocharis* occur, *Deltoccephalus gnarus* is found.

Isolated Grass Areas.—Some of the most interesting captures were made in areas where isolated islands of more western vegetation are still present. One such area is a pure stand of small grass several feet square which is growing upon the high exposed cliffs west of the stream at White Pines Forest State Park. *Laevicephalus minimus* was collected in abundance in this habitat. On the shaded grasses under the pine trees *Palus detector* was found.

A similar type of habitat was found at Apple River Canyon State Park. There a stream has cut a deep gorge, leaving high rock-faced cliffs upon which are several types of wooded and herbaceous vegetation. Species like *Chlorotettix unicolor* and *balli* are rather abundant on the grasses of the flood plain. The grasses in the wooded areas support *Chlorotettix lusorius* and *Colladonus furculatus*. The entomologist who wishes to expend the energy to climb to the top of the rugged cliffs and search out small patches of short grasses is well repaid for his efforts by finding *Flexamia pectinata* in specific spots or pockets on the western cliffs. East and south of the Canyon in a similar situation *Polyamia dilata* and *saxosa*, rare in the state, and *Hebecephalus signati-*

frons may be found. The last mentioned species is more often found west of Illinois and may reach its eastern limit in this state.

Marshes.—Marsh grasses and sedges furnish another series of interesting habi-



Fig. 5.—Meadows of *Calamagrostis* and associated grasses in old lagoons of Lake Michigan, near Zion, Illinois.

tats. Along Lake Michigan, from Waukegan to Zion, extensive meadows of *Calamagrostis*, fig. 5, and associated grasses have developed from the old lagoons which were originally formed along the shores of Lake Michigan by wave action. On these grasses occur *Amplicephalus osborni*, *Limotettix striolus* and *parallelus*, *Chlorotettix spatulatus*, *fallax*, *obsenus*, and *Hecalus lineatus*. In the swamp portion, where the water table is closer to the surface, *Macrostelus potoria* and *slossoni* are found.

At the shallow margins of Fox Lake, fig. 6, and other northern Illinois lakes are often formed large areas that are filled with species of *Typha*, *Spartina*, and associated sedges and grasses. These associations abound in *Cicadula cyperacea*, *melanogaster*, and *smithi* (on *Spartina Michauxiana*) and *Euscelis sahlbergi*. The smaller grasses in these habitats often support species of *Paraphlepsius*, such as *humidus* and *altus*. In other marshes, fig. 7, are clumps of sedges



Fig. 6.—Marshes of varied floral content along the edges of Fox Lake, Illinois. Here is found a large variety of sedge and grass feeding leafhoppers.

that harbor *Laevincephalus shingwauki* and *Parabolocratus viridis*.

Associated with the cypress swamps of southern Illinois, as at Karnak and Olive Branch, are marshes that contain tall grasses and sedges upon which occur *Chlorotettix dentatus*, *melanotus*, and *limosus*.

In the marshes of the Chicago area is an abundance of *Hecalus lineatus* and *Para-*

bolocratus viridis, *major*, and also *grandis*.

The tamarack bog at Volo contains large areas of *Vaccinium*, fig. 8, upon which live species of *Ophiola*.

Woodland Areas.—One of the most interesting habitats found in the state is the Herod flood plain, a low flat wooded area which is only a few feet above the stream bed and which is furnished with a high



Fig. 7.—Especially rich in leafhopper species are marshes such as this one at Volo, Illinois, along the edge of a tamarack bog.

water table and a resultant moist soil condition, thus producing a luxuriant growth of vegetation composed of cane (*Arundinaria tecta*), several types of grasses, many

species found in this association are *Polyamia interrupta*, *Chlorotettix nudatus*, *Iusorius melanotus*, and *Paraphlepsius fulvidorsum*. Where *Impatiens* is found growing



Fig. 8.—Leafhoppers of the genus *Ophiola* are found on *Vaccinium*, which grows extensively in a bog near Volo, Illinois.

annual herbaceous plants, and a few perennials. On the cane were found several species of *Arundanus*, namely, *nacreosus*, *flavotinctus*, *marginellus*, and *arundineus*. *Chlorotettix suturalis*, and *Polyamia arundinea*. The grasses and herbaceous plants support several species, the more interesting of which are *Chlorotettix iridescens*, *balli*, and *nudatus*, *Paraphlepsius rossi*, *Kolla geometrica*, and *Polyamia alboneura*. Upon the small grasses at the margin of the stream in this shaded habitat is found *Polyamia brevipennis*.

The wooded areas, fig. 9, produce a variety of types of associations in different areas of the state. A wooded glen at Rocky Branch, Dolson, proved to be one of the areas containing the greatest abundance of species of leafhoppers. Several species of *Cloanthanus* and several species of *Scaphoideus* including *nigrellus*, which was taken only at this point, occur in this association. The association is composed of an open mixed mesophytic forest with a luxuriant growth of shrubs and herbaceous vegetation, some of which occur in rather low moist areas and some of which are found only on well-drained slopes. Some common

in shaded areas, *Macrosteles variata* occurs.

Near Shawneetown in the Ohio River area are shaded meadow grasses in low areas; upon the luxuriant growth occur such species as *Chlorotettix attenuatus* and *balli* and *Paraphlepsius latifrons*. At Vienna and Savanna where other types of open woodland are found, *Ophiola anthracina* and *Osbornellus unicolor* occur on the herbaceous vegetation.

In several places such as Oakwood and Eichorn, large patches of wild rice (*Elymus*) are growing in shaded places along streams or in low flat woods. On this food plant are found specimens of *Elymana inornata* and *acrita*.

The woodland trees themselves, in addition to furnishing shaded conditions for herbaceous plants, support several species of leafhoppers. Certain genera are apparently limited in their feeding habits to species of trees. As an example many of the species of *Idiocerus* occur upon willows: *Idiocerus snowi*, *alternatus*, *pallidus*, and *moniliferae*. In addition *Macropsis viridis*, *Empoasca obtusa*, *Neokolla hieroglyphica*, and other leafhoppers are found on willows. The



Fig. 9.—A lush growth of herbs in a wooded glade at Starved Rock State Park, Illinois. Such a habitat supports a leafhopper fauna very different from that found in the prairies.



Fig. 10.—Rolling hills near Elizabeth, Illinois. Both the open prairie and the hazel and aspen clumps (center background) have a distinctive leafhopper fauna.

Carolina poplar is a tree occurring in the same habitat with the willow which supports species of *Idiocerus* and *Macropsis*. Upon Lombardy poplar have been found *Idiocerus scurrus* and *Fieberiella florii*; the latter species also occurs upon some of the ornamental shrubs. A common ornamental shrub, *Tamarix*, which grows wild in certain areas of the United States, supports large populations of a bright green leafhopper, *Opsius stactogalus*. Certain species of oak are food plants for *Alebra albostrigella*, *Eutettix pictus* and *luridus*, and *Penthimia americana*. The maples are usually infested with *Japananus hyalinus*. The walnut is the food plant for *Oncopsis verticis*, and the honey locust supports *Stragania apicalis* and *Macropsis fumipennis* var. *gleditschiae*. Species of *Crataegus* are the food plants of *Idiocerus crataegi*, *fitchi*, and *provancheri*. Certain species of *Scaphoideus*, *Gyponana*, and *Ponana* live normally upon American elm. *Idiocerus hebetus* is a common species on quaking aspen. *Scaphoideus opalinus*, *Idiocerus apache* var. *juniperus*, and *Empoasca junipera* are common species on juniper. These and many other species occur upon our common species of trees, but more especially should be mentioned the fact that practically all species of forest and shade trees are food plants for many species of *Erythroneura*, *Empoasca*, and *Typhlocyba*, genera which have been mentioned only superficially in the present study.

Open Hillsides.—The hillside pastures and short grass meadows of the Ozark foothills in the southern portion of the state present interesting associations and here many species have been taken in a single pasture. Space prevents the enumeration of all such species but the more common and interesting are *Acurhinus pyrops*, *Paraphlepsius irroratus*, *truncatus*, *tennessa*, and *pusillus*, *Texananus superbus*, *Chlorotettix galbanatus*, *necopinus*, and *viridius*, *Polyamia inimica*, *weedi*, *obtecta*, and *similiaris*, *Flexamia picta* and *inflata*, and *Deltocephalus sonorus* and *flavicosus*.

The hillside pastures of the Jo Daviess hills, fig. 10, in the northwestern corner of the state contain several of the same species. In addition to those, *Athysanella acuticauda* is a common species in this northwestern pasture region. Many other species of leafhoppers occur on the open prairie and in the hazel and aspen clumps of this part of the state.

ECONOMIC STATUS

Several species of Illinois leafhoppers are known as pests of various plants and crops. Thin piercing-sucking mouthparts injure plants by piercing the cells and vessels of the leaf or stem and sucking out the plant fluids. Slight injury may also be caused by the egg punctures of the larger species, which oviposit in leaf tissues.

The potato leafhopper, *Empoasca fabae*, is a major pest of potatoes in Illinois. The browning and curling leaf injury known as hopperburn apparently is caused by this leafhopper through the plugging of the conductive tissues of the stalks or veins. Where such injury occurs it prevents the manufacture and translocation of starches in the plant and usually the formation of potato tubers. This type of injury is not produced by other species of leafhoppers.

The rapid multiplication and growth of potato leafhoppers results in heavy populations and severe injury to potatoes in seasons of normal climate. Heavy populations of this pest also cause injury to other crops. Beans are injured by a cupping or curling of the leaves with the top of the leaf appearing humped. A hopperburn condition is often produced on rhubarb. On alfalfa a yellowing of the leaves is caused by leafhoppers, and young apple trees are frequently injured by the insects, which cause a severe curling of the newer leaves.

Apples are injured severely in certain seasons by leafhoppers of several genera. Species of *Erythroneura* and *Typhlocyba*, as well as *Empoasca*, cause damage, and species of *Gyponana*, *Idiocerus*, and other genera may occasionally become pests. The more abundant and common species infesting apples are *Erythroneura lawsoniana*, *maculata*, *obliqua*, *hartii*, and *ziczac*, *Typhlocyba pomaria*, and *Empoasca fabae* and *maligna*.

The species of *Erythroneura* hibernate as adults and lay eggs on the young developing shoots or leaves of apple in May and June. The eggs of *Typhlocyba pomaria*, *Empoasca maligna*, and of species of *Gyponana* and *Idiocerus* pass the winter in the bark of twigs and hatch early in the spring. In view of this fact, the populations upon the apple tree are composed of a complex of adults and immature forms of the various species. Severe populations cause the leaves to become stippled with white puncture

spots and often to turn brown and fall. When the apples are ripening in the autumn, the populations are often so abundant that the fruit is coated with "honeydew" excretions. It is common for the sooty fungus to grow in this excretion. The large *Gypsonana* leafhoppers make rather large egg punctures in the new twig growth. These leafhoppers probably are not of economic importance, but they leave large scars and occasionally become abundant. It is difficult to control them.

Certain species of *Erythroneura*, especially *comes* and *tricincta*, usually become pests of grapes, attacking the leaves and causing them to turn whitish, then yellow, and finally brown before they fall to the ground prematurely. By the time this partial defoliation occurs, the grapes are fully developed but not matured. The green leaves are necessary to produce the sugars for maturing the fruit. As a result of leafhopper attack, the marketed grapes are often sour and the quality is decidedly impaired by leafhopper defoliation.

Clover and alfalfa harbor a number of leafhopper species, among which are *Aceratagallia sanguinolenta*, known as the clover leafhopper, *Polyamia inimica*, *Unerus nigrifrons*, *Exitianus obscurinervis*, *Macrostes divisa*, *Agallia constricta*, *Cloanthanus frontalis* and *acutus*, and *Empoasca fabae*. The most severe leafhopper pest of alfalfa is undoubtedly *Empoasca fabae*.

Forage crops of all kinds are attacked by leafhoppers, which are usually considered as minor pests of these crops but occasionally become quite abundant. The leafhoppers most often present on forage crops are *Draeculacephala* spp., *Graminella nigrifrons*, *Polyamia inimica*, *Exitianus obscurinervis*, *Macrostes divisa*, *Psammotettix striatus*, *Paraphlepsius irroratus*, and *Cloanthanus* spp.

In addition to causing injury by direct attacks, certain species of leafhoppers are important as vectors in the transmission of plant diseases. The sugar beet leafhopper, *Norvellina tenella*, one of the best known of this group, transmits to sugar beet and other plants the virus disease causing curly top. In the early 1930's this disease was found on horse-radish in Illinois, associated with large populations of the vector. That infestation was apparently caused by a migration; leafhopper and disease disappeared in 1937 and have not recurred in Illinois since.

Macropsis trimaculata has been proved to transmit yellows, a disease fatal to peach trees. *Macrostes divisa*, a common species on many types of plants, has been proved to be vector of another virus disease, aster yellows.

Where cranberries are grown commercially in the northern bog areas, *Ophiola striatula* and *osborni* are pests; the former has been demonstrated to be the vector of a virus disease known as false blossom of cranberries. Yellow dwarf of potatoes has been readily transmitted by *Aceratagallia sanguinolenta*.

TAXONOMY

The Cicadellidae are most readily distinguished from other families of Homoptera by two rows of prominent spines on the long hind tibiae. The head usually bears two ocelli well separated from the large compound eyes by the basal portion of the vertex. Throughout the group the vertex varies greatly in length and general structure. In some genera it is very short and parallel margined and in others extremely long and foliaceous. Each of the first pair of wings has a definite claval area and a corium. The clavus in some genera is reticulate veined. In most genera the corium is crossed by two veins, frequently called the first and second sectors; the first sector is branched on the corium, forming an outer and inner branch; and there are usually one or two crossveins between the first and second sectors, always a row of apical veins, and usually a row of anteapicals. In a few species both brachypterous and macropterous forms occur.

In size, individuals of this group range from 3 to 12 millimeters in length. Usually the females are larger than the males and often differ from them in color and structure.

Some of the more recent and useful papers on the taxonomy of leafhoppers are by Johnson (1935) on the Cicadellinae (Typhlocybinae) of Ohio, Oman (1937, 1938a) on some North American and South American leafhopper genera, and Osborn (1928) on Ohio leafhoppers. Other useful works are a publication on Minnesota leafhoppers by Medler (1942), and a check list of Nearctic leafhoppers by DeLong & Knoll (1945). These references contain many bibliographic citations to the Cicadellidae.

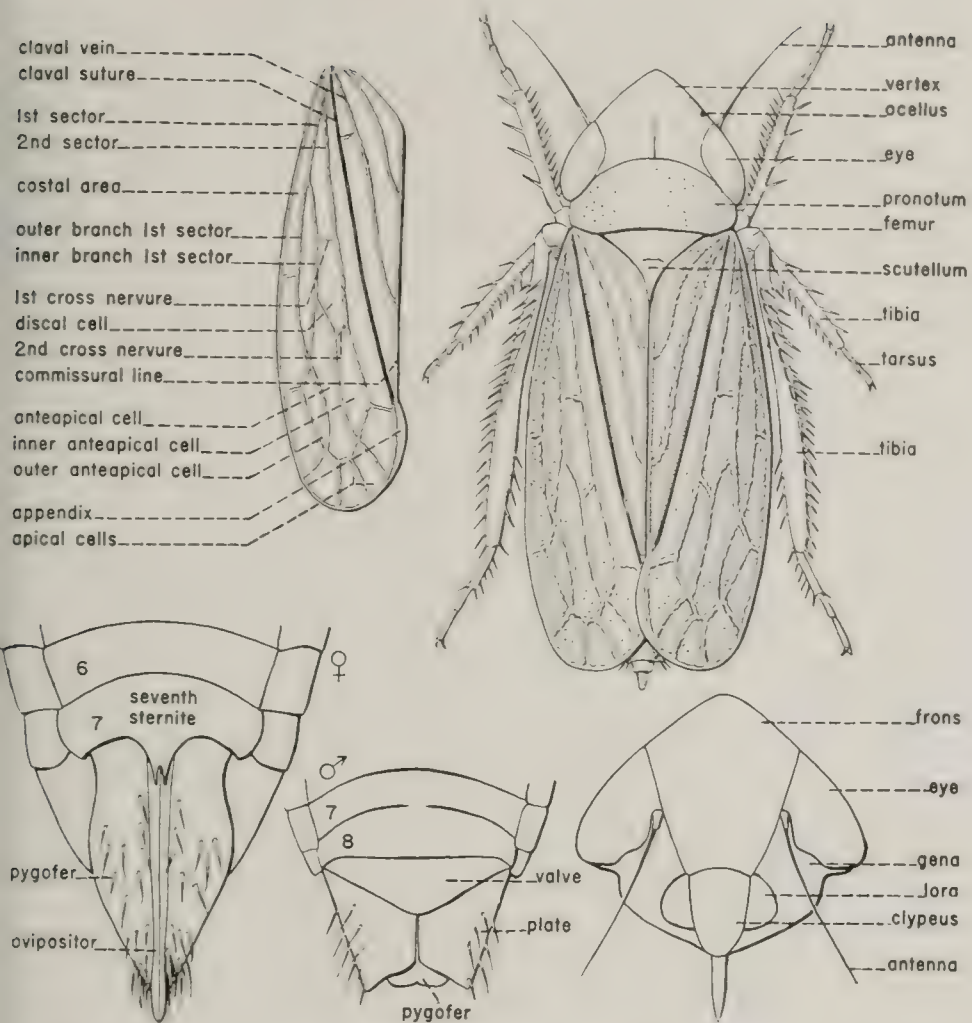


Fig. 11.—*Latulus configuratus*. Figures illustrating terminology for parts of body, elytron, and male and female external genitalia.

Systematic Characters.—The Cicadellidae are divided into subfamilies chiefly on the basis of position of ocelli, sutures of head, shape of pronotum, and venation, fig. 11. The general type and comparative length of head and the curvature of the vertex or the presence or absence of a foliaceous margin assist in the separation of genera in certain groups. Wing venational patterns, the presence or absence of certain branches, and the presence or relative numbers of reticulate crossveins or reflexed costal veinlets are valuable characters for generic distinctions. In the Cicadellinae the second pair of wings contains diagnostic

venational characters in addition to those in the first pair of wings. The generic separation of the members of this subfamily may be accomplished almost entirely upon the basis of wing venation. The male genital structures often assist in placing a species in its genus even though the entire specimen except this portion may be missing. In most leafhopper groups the internal chitinous pieces of the male genitalia, fig. 12, are the most reliable structures known to date for specific diagnosis. In certain genera, those of the Macropsinae for example, we have been unable to date to distinguish the species by the genitalia; hence their species

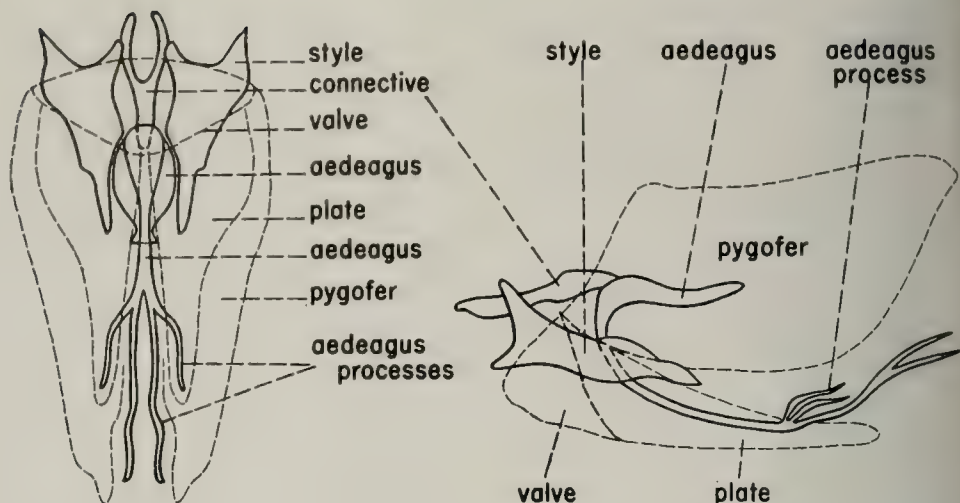


Fig. 12.—*Chlorotettix dentatus*. Figures of male internal and external genitalia illustrating terminology of parts.

are separated largely on the basis of color patterns. The external structures of the male are often very useful for separating species, but as a rule the internal structures of the genital cavity are more specific, especially the aedeagus and paired styles. In certain genera the shape and excavation or curvature of the posterior margin of the seventh sternite of the female, designated in some publications as the last ventral segment, is excellent for species separation. In other groups, the female seventh sternite in as many as 50 or more similarly colored or marked species may be identical. In such cases it is almost impossible to key the females to species. Insofar as possible, both sexes have been keyed to species in this report. Even when not used in the keys, the male genital structures have been illustrated if of value in assisting students to check the identity of species.

The keys to the subfamilies and genera were devised largely for the separation of the members of groups known to occur in Illinois and nearby states.

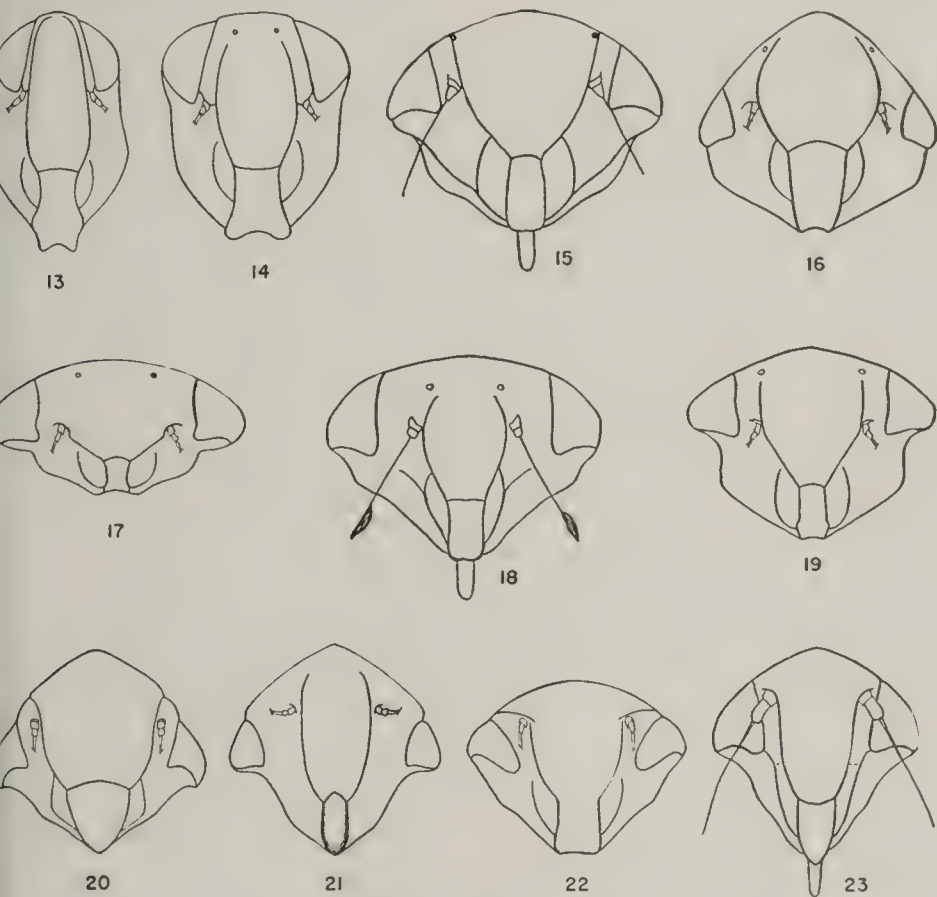
KEY TO SUBFAMILIES

1. Frons long and nearly parallel sided or a little narrowed dorsad, figs. 13, 14; eyes large and separated on meson by less than greatest width of eye, fig. 24.**Jassinae**, p. 343
- Frons expanding dorsad, as in figs. 15, 16; eyes smaller and usually separated on meson by one or more times width of eye.2

2. Vertex between eyes very short and from 5 to 13 times wider than median length, as in figs. 26, 29; ocelli on extreme front margin of vertex or on face, as in figs. 17, 18.3
- Vertex between eyes generally long and 2 to 4 times wider than median length, as in figs. 28, 31; ocelli above, or on front margin of vertex, or absent, as in figs. 27, 31.9
3. Anterior margin of pronotum extended beyond a line through the anterior margins of eyes, as in fig. 26.4
- Anterior margin of pronotum not extended beyond anterior margins of eyes, as in figs. 27, 29.6
4. Frontal suture extending beyond antennal pit and curved on inside of ocellus, fig. 16; veins of elytra each with a double row of punctures on margins, fig. 95.**Nioninae**, p. 131
- Frontal suture ending at or near antennal pit, figs. 92, 93; veins of elytra without punctures.5
5. Vertex obtusely angulate, fig. 26; anterior margin of pronotum produced from one-third to nearly one-half its length beyond anterior margins of eyes; head and pronotum punctured or with irregular raised lines.**Macropsinae**, p. 123
- Vertex broadly rounded, figs. 96, 104; anterior margin of pronotum produced not more than one-fifth or one-sixth its length beyond anterior margins of eyes; head and pronotum finely granulate.**Agalliinae**, p. 132
6. Frontal suture extending beyond antennal pit nearly to ocellus, as in fig. 19; head wider than pronotum; elytra bare between veins.7
- Frontal suture ending at antennal pit, as in fig. 17.8

7. Body large and robust, the elytra inflated behind; ocellus, fig. 19, closer to eye than middle of vertex and directly above antennal base. The genus *Remadosus* in..... **Athysaninae**, p. 181
 Body slender, fig. 34, the elytra narrowed behind; ocellus, fig. 18, almost exactly halfway between eye and middle of vertex on inside of a perpendicular line through antennal base..... **Eurymelinae**, p. 111
8. Head, fig. 29, narrower than pronotum; elytra with many short hairs between veins..... **Bythoscopinae**, p. 138
 Head, fig. 98, wider than pronotum; elytra bare. The genus *Aceratagallia* in..... **Agalliinae**, p. 132
9. A median longitudinal carina on front and on vertex, and another extending from

- inner margin of eye to middle of front margin, fig. 30..... **Evacanthinae**, p. 153
 Carina absent on front and only occasionally present on vertex..... 10
 10. Ocelli on disc of vertex between eyes but remote from eyes and anterior margin, figs. 31, 33..... 11
 Ocelli, when present, on or near anterior margin of vertex, as in figs. 205, 206..... 14
 11. Each clavus without veins or stripes; terminal membrane of each elytron, fig. 152B, wide on inside and broadly overlapping at suture; body short and broad, with apex of elytra conspicuously sloping..... **Penthimiinae**, p. 154
 Each clavus with one or more distinct veins or veinlike dark stripes, as in figs. 128-130; terminal membrane on



Faces of Cicadellidae

Fig. 13.—*Tinobregmus viridescens*.Fig. 14.—*Jassus olitorius*.Fig. 15.—*Chlorotettix unicolor*.Fig. 16.—*Nionia palmeri*.Fig. 17.—*Stragania apicalis*.Fig. 18.—*Idiocerus lachrymalis*.Fig. 19.—*Remadosus magnus*.Fig. 20.—*Neokolla hieroglyphica*.Fig. 21.—*Xerophloea major*.Fig. 22.—*Ponana quadralaba*.Fig. 23.—*Typhlocyba tunicarubra*.



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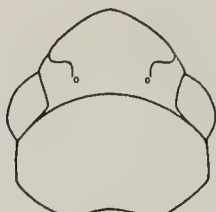
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Heads of Cicadellidae

- Fig. 24.—*Jassus olitorius*.
 Fig. 25.—*Nesosteles neglectus*.
 Fig. 26.—*Macropsis viridis*.
 Fig. 27.—*Xestocephalus pulicarius*.
 Fig. 28.—*Balclutha abdominalis*.
 Fig. 29.—*Stragania apicalis*.
 Fig. 30.—*Evacanthus acuminatus*.
 Fig. 31.—*Neokolla hieroglyphica*.
 Fig. 32.—*Aphrodes nervosus* ♀.
 Fig. 33.—*Gyponana octolineata*.

- inner margin of each elytron at apex narrow, and at most only narrowly overlapping; body more elongate. 12
12. Frontal sutures extending over anterior margin of vertex nearly to ocelli, figs. 20, 31; margin of vertex very blunt and broadly rounded to front, or bulbous. *Tettigoniellinae*, p. 139
- Frontal sutures terminating below anterior margin of front, as in figs. 21, 22; margin of vertex not more than slightly thickened, sometimes thin and foliaceous. 13
13. Clypeus, fig. 21, small, oval, very convex; antennal pit with a slight rounded convexity in front; dorsum, fig. 182, nearly uniformly covered with deep rounded pits. *Ledrinae*, p. 169
- Clypeus, fig. 22, larger, parallel sided, slightly convex; antennal pit with a distinct transverse sharp ridge above, reaching eye; body not pitted though shallowly punctured along veins. *Gyponinae*, p. 155
14. Elytra, fig. 403, short and broadly rounded, exposing five or more abdominal segments; nearly all veins, if distinct, reaching apical margin and usually without closed cells on disc before elytral apex, as in fig. 237. *Athysaninae*, p. 181
- Elytra long, as in fig. 229, and exposing at most the tip of abdomen; at least two or more distinct cells on disc of each elytron, as in figs. 200, 230. 15
15. Elytral nervures usually not branching on disc and without crossveins anterior to apical crossveins, figs. 490-499; ocelli often absent; lorae usually long and narrow, fig. 23. *Cicadellinae*, p. 349
- Either elytral nervures branching on the disc, or crossveins present anterior to apical crossveins, figs. 211-230; ocelli usually present; lorae not especially elongated, fig. 15. 16
16. Ocellus distant from eye, located approximately half way between inner margin of eye and middle of front margin, fig. 27. 17
- Ocellus very close to eye at no more than one-third the distance between inner margin of eye and middle of front margin, and situated on front margin or only slightly behind, as in figs. 186A, 188. 20
17. Vertex raised in front of and above eye so that eye appears to be somewhat sunken in head, fig. 487. *Neocoelidiinae*, p. 345
- Vertex not raised in front of or above eye, the vertex appearing to be nearly continuous with eye, as in fig. 25. 18
18. Margin of vertex bluntly to evenly rounded to face, fig. 197, and with ocelli situated on or appearing to touch extreme front margin when viewed from above, fig. 27. 19
- Vertex more angulate with the front, and with ocelli a little behind front margin. *Aphrodinae*, p. 178
19. Head narrower than pronotum, fig. 27;

- apexes of elytra mottled brown. The genus *Xestocephalus* in.....
- **Aphrodinae**, p. 178
- Head wider than pronotum, fig. 463; apexes of elytra not mottled brown, though often dark with light veins. The genus *Cicadula* in.....
- **Athysaninae**, p. 181
20. Vertex produced, anterior margin thin, sharp, and foliaceous, figs. 186-190.....
- **Dorydiinae**, p. 170
- Vertex often flattened and acutely angled but rarely thin, sharp, and foliaceous on entire margin, figs. 200, 210..... 21
21. Inner sector of forewing twice forked, forming three anteapical cells, fig. 214; hind wing with four apical cells.....
- **Athysaninae**, p. 181
- Inner sector of forewing not forked, with two anteapical cells, fig. 213; hind wing with three apical cells..... 22
22. Head distinctly narrower than pronotum, or, if as wide, then with vertex broad, almost parallel margined, scarcely produced at middle, and without definite color markings, figs. 28, 488.....
- **Balcluthinae**, p. 346
- Head as wide as or wider than pronotum, figs. 469, 472; vertex produced at middle, usually bluntly angled, marked with black spots or broken transverse bands.....
- **Athysaninae**, p. 181

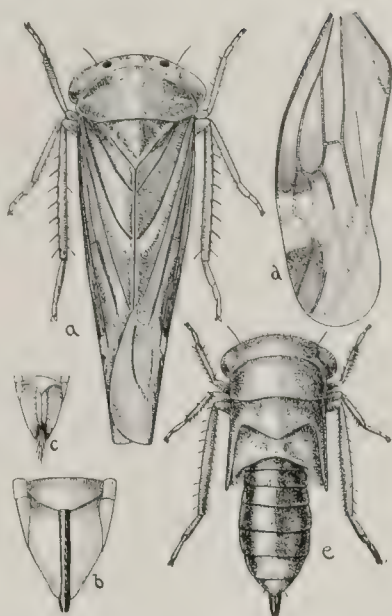


Fig. 34.—*Idiocerus fitchi*: a, adult; b, female genitalia; c, male genitalia; d, elytron; e, nymph. (From Osborn.)

Subfamily EURYMELINAE

The members of this subfamily are wedge shaped in appearance and have short broad vertexes that are rounded to the front; the ocelli are on the face. Each of the forewings has a large and distinct appendix.

This group is represented in the United States by only one genus, *Idiocerus*.

1. IDIOCERUS Lewis

Idiocerus Lewis (1835, p. 47).

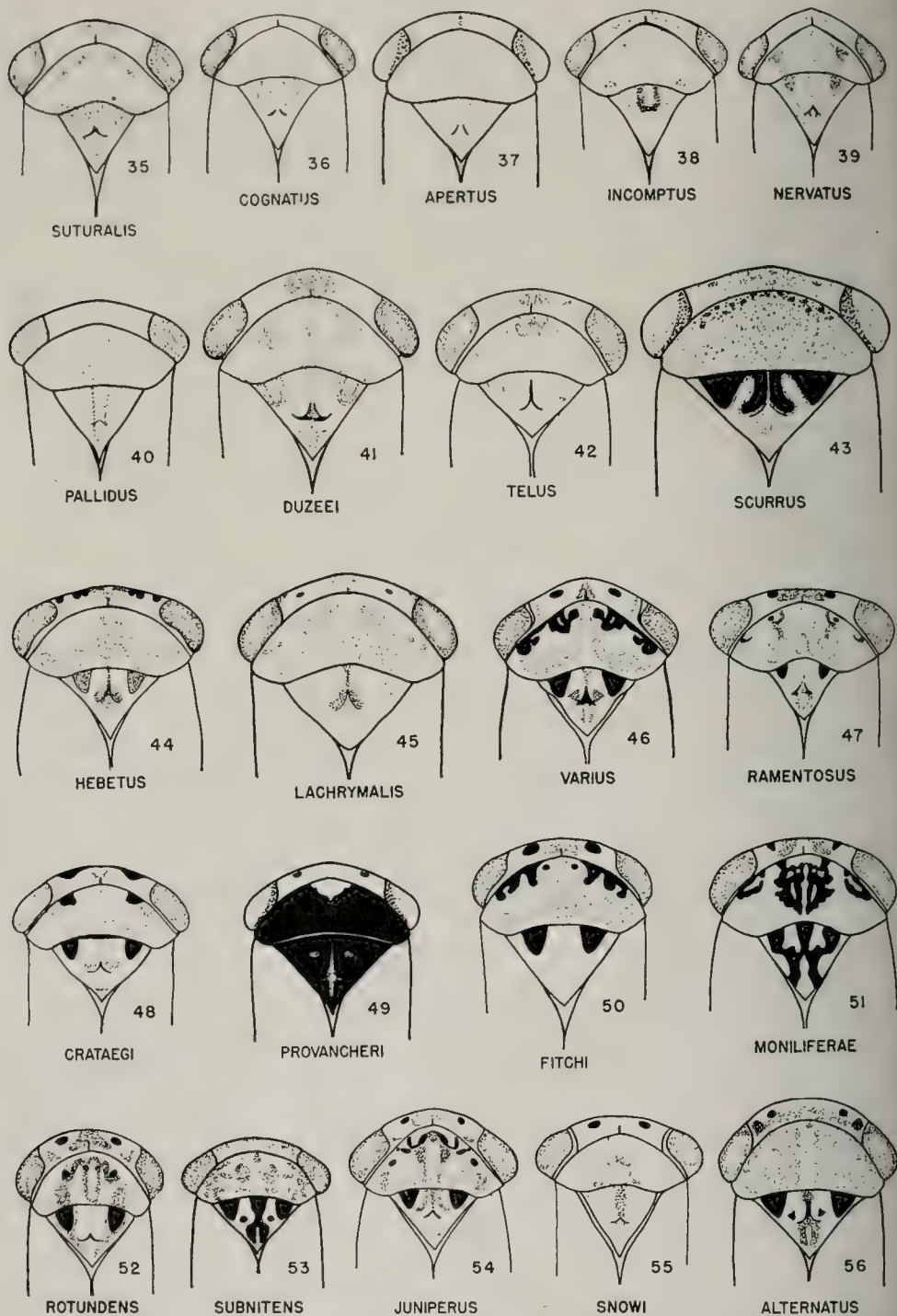
Fig. 34. Head short, broader than pronotum. Vertex short, parallel margined, and broadly rounded to front. Male antennae frequently bearing characteristic discs near their apexes. Elytra usually longer than abdomen, narrow, each with a distinct appendix, narrowly rolled or folded at apex.

So far as is known this group is entirely tree or shrub inhabiting, and the greater number of species occur on willow, poplar, aspen, and species of *Crataegus*. About 75 species and varieties occur in the United States; 17 have been collected in Illinois.

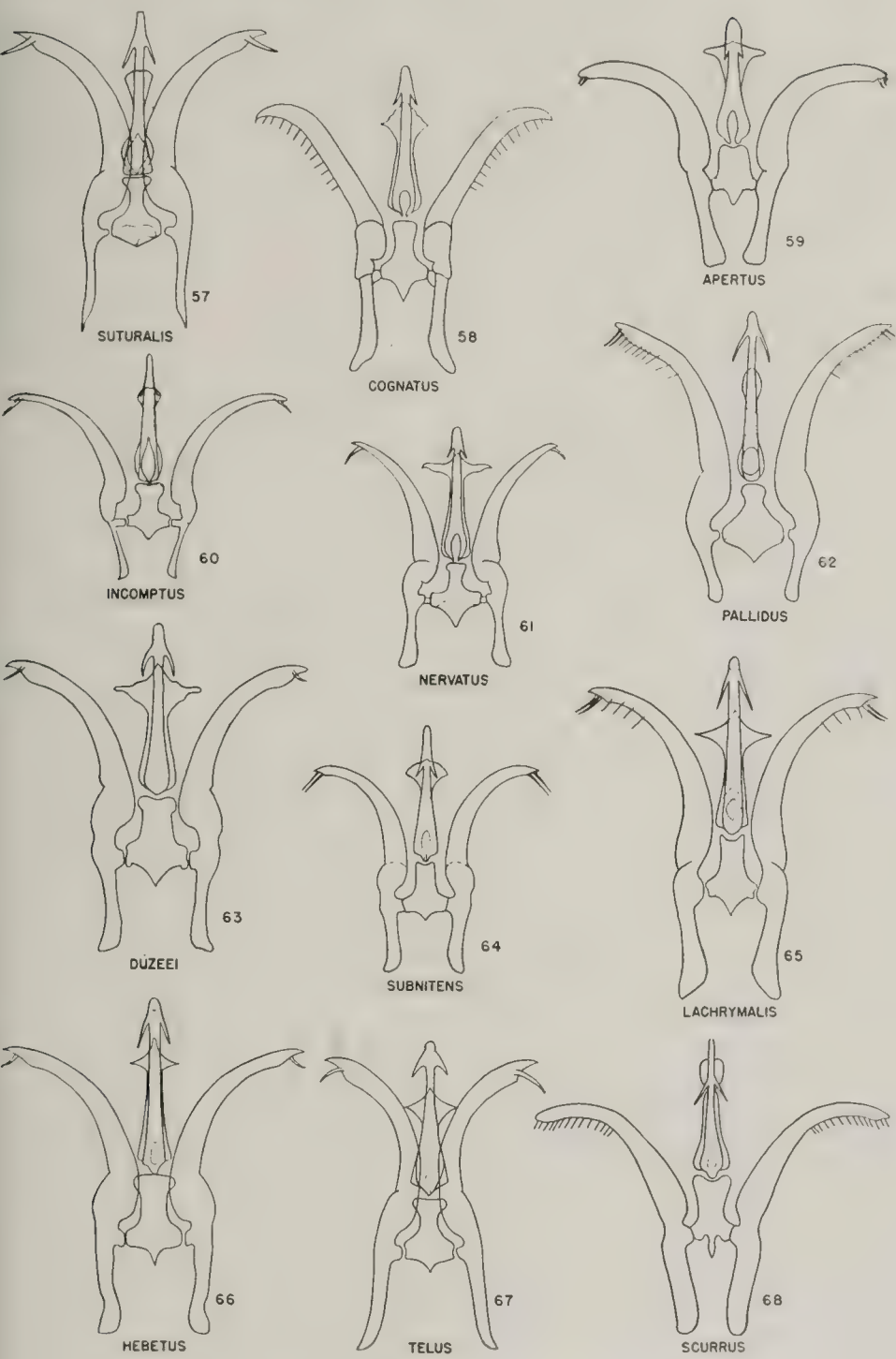
KEY TO SPECIES

1. Vertex without definite round black spots on margin, figs. 35-45..... 2

- Vertex marked with two or more round black spots on margin, figs. 46-56..... 12
2. Pale yellow or green, with a broad fuscous stripe arising on scutellum, fig. 35, and extending along inner margins of elytra to apex of clavus, often broken or interrupted..... **1. suturalis**
- Green, yellow, or brown, but without a stripe along inner margins of elytra..... 3
3. Length not exceeding 5.0 mm..... 4
- Length 5.5 mm. or more..... 7
4. Pronotum and scutellum irrorate, fig. 37; elytra fuscous, costal margins white.....
- **3. apertus**
- Pronotum and scutellum not irrorate, elytra not fuscous; color pale green or yellow..... 5
5. Elytra pale, faintly banded by pale bronze or fuscous transverse bands; each male antenna simple..... **2. cognatus**
- Elytra pale, not banded or marked; each male antenna with small disc..... 6
6. Dorsal portion of aedeagus, fig. 60, terminating in a small narrow rounded process..... **4. incomptus**
- Dorsal portion of aedeagus, fig. 61, transverse, with lateral pointed processes widely produced..... **5. nervatus**
7. Elytra green or iridescent gold, not marked with brown..... 8
- Elytra brown, with pale markings, or pale, with brown markings..... 10
8. Elytra white or pale green; each male antennal disc elongate, ovate..... 9
- Elytra iridescent gold; each male antennal disc broader, elongate, subovate..... **7. duzeii**



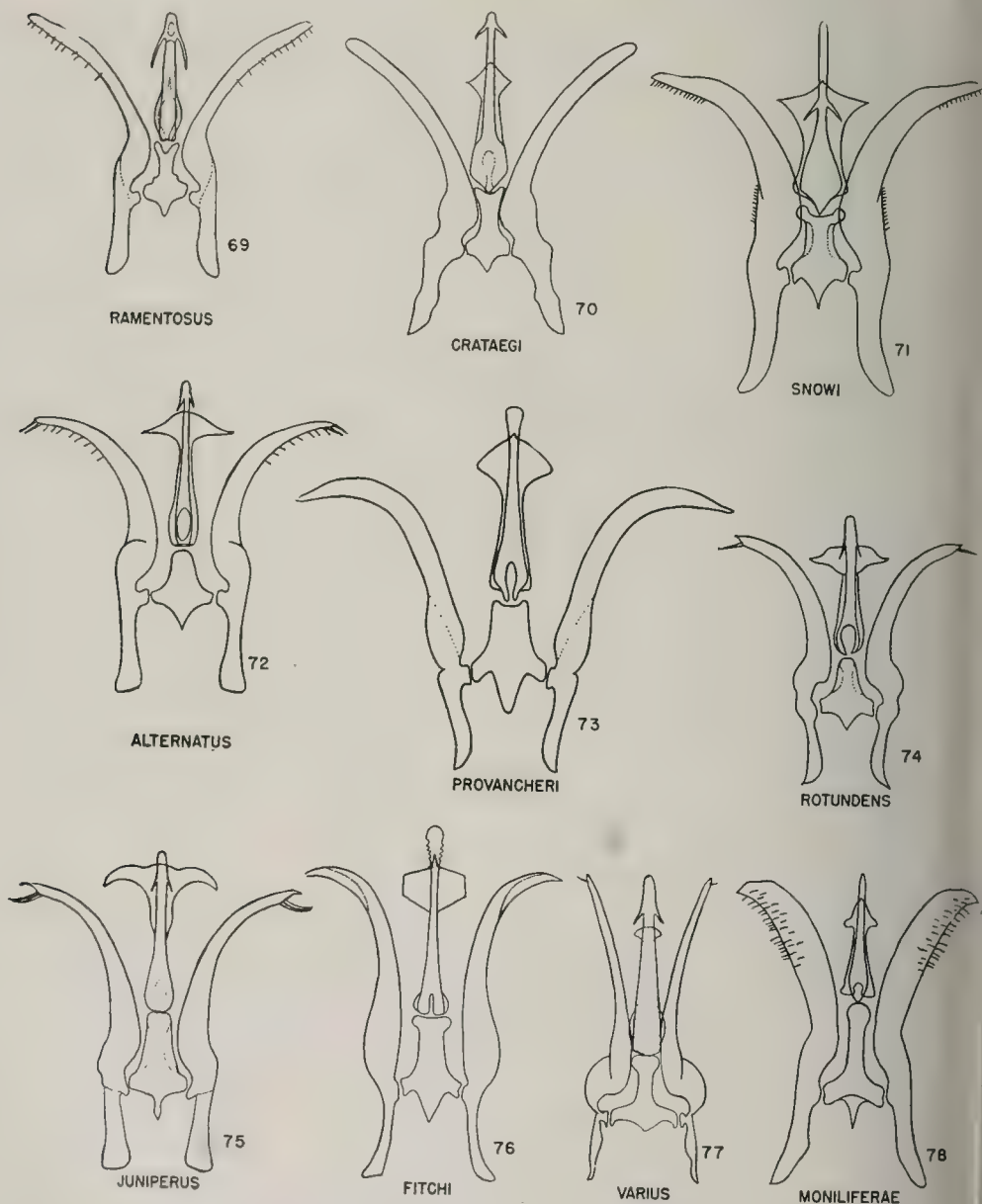
Figs. 35-56.—*Idiocerus*, head, pronotum, and scutellum. Color patterns and shapes of typical representatives of 22 species are shown.



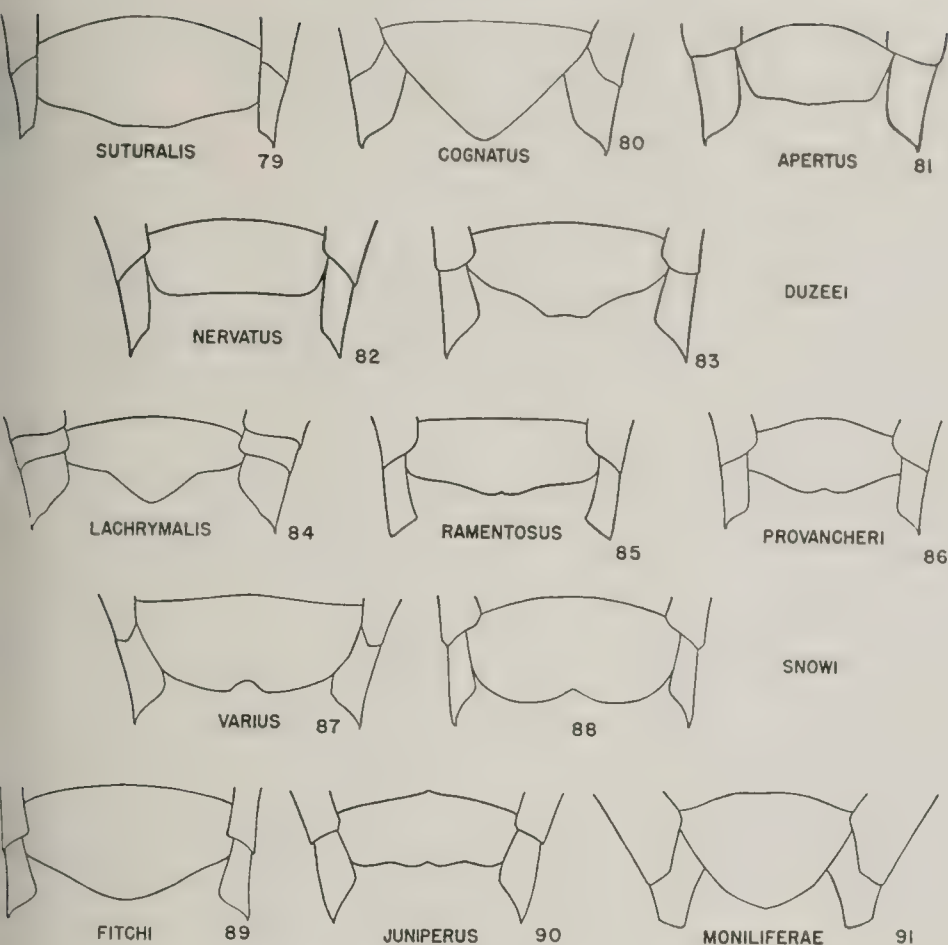
Figs. 57-68.—*Idiocerus*, male genitalia.

9. Dorsal portion of aedeagus, fig. 62, narrow and rounded at apex; spines at terminus of ventral portion long, not webbed to aedeagus shaft. **6. pallidus**
 Dorsal portion of aedeagus, fig. 67, terminating in a broad diamond-shaped process; spines at the terminus of ventral aedeagus process appearing webbed to aedeagus shaft. **8. telus**
 10. Elytra brown, with pale spots on veins, especially on each clavus; each male

- antenna simple, without disc. **9. scurrus**
 Elytra white, veins marked with brown; each male antennal disc large, elongate, and black. **11**
 11. Pale, without conspicuous dark markings, fig. 44; each style, fig. 66, with one prominent spine at apex; diamond-shaped terminus of dorsal aedeagus process small. **10. hebetus**
 Usually with darker conspicuous color



Figs. 69-78.—*Idiocerus*, male genitalia.

Figs. 79-91.—*Idiocerus*, female seventh sternite.

- markings; each style, fig. 65, with two prominent proximal parallel spines at apex; diamond-shaped terminus of dorsal aedeagus process large, conspicuous, **lachrymalis** (see 10. *hebetus*)
12. Elytra marked with a white transverse band at apex of each clavus. **11. subnitens**
Elytra often mottled but without a white transverse band at apex of each clavus. 13
13. Vertex marked by a transverse brownish band variously intensified, as in figs. 44, 45, frequently enclosing the round black spots. 14
Vertex without a transverse brown or black band. 15
14. Pale, without conspicuous dark markings; style, fig. 66, with one prominent spine at apex; diamond-shaped terminus of dorsal aedeagus process small. **10. hebetus**
Usually with darker conspicuous color markings; style, fig. 65, with two prominent proximal parallel spines at apex; diamond-shaped terminus of dorsal aedeagus process large, conspicuous **lachrymalis** (see 10. *hebetus*)
15. Black spots on vertex large, appearing proximal to eyes. 16
Black spots on vertex not more than half as large, often very small, appearing more distant from eyes. 19
16. Color rather uniform, pale or dull brown, without markings; elytra brownish hyaline, veins often darker. **12. ramentosus**
Color not uniform, but pale brown marked with black and yellow, or dark brown, with pale markings. 17
17. Dirty yellow to pale gray; a pair of black spots on anterior margin of pronotum, fig. 48; basal angles of scutellum black; elytra pale, subhyaline, veins brown. **13. crataegi**
Dark brown or chestnut brown, pronotum and scutellum with pale markings. 18
18. Basal two-thirds of elytra entirely white,

- tinted with yellow except for a broad black band on inner margin next to scutellum; scutellum, fig. 49, nearly uniform chestnut brown
14. *provancheri*
Basal portion of each clavus pale brown, with darker veins and a small white spot at apex of second claval vein; scutellum, fig. 50, mostly white, lateral and apical portions white.
15. *fitchi*
19. Elytra marked by two faint transverse bronze or pale brownish bands.
2. *cognatus*
Elytra marked with dark brown and without definite bands. 20
20. Veins concolorous or uniform yellowish; body pale in color. 21
Veins alternately white and dark brown; body darker in color. 22
21. Length 5.25–5.75 mm.; usually with a narrow brown stripe extending along claval portion of inner margins of elytra; each male antenna without disc.
16. *snowi*
Length not exceeding 5.0 mm.; basal angles of scutellum, fig. 52, with brown triangular spots, but without markings on elytra; each male antenna with large oval disc.
17. *rotundens*
22. Brownish in color; veins alternately brown and white, not conspicuously marked; each male antennal disc elongate, black. 23
Darker brown, more heavily marked on vertex, pronotum, scutellum, and elytra, fig. 51; veins broadly, heavily, and more conspicuously marked with alternating brown and white areas; each male antenna simple, without disc.
21. *moniliferae*
23. Dorsal process of aedeagus, fig. 77, small, rounded at apex, scarcely broader than ventral aedeagus shaft.
18. *varius*
Dorsal process of aedeagus broad, terminal processes laterally pointed or hooked, as in figs. 72, 75. 24
24. Dorsal aedeagus process, fig. 75, with lateral terminal portions bent anteriorly, gradually curved concavely on anterior margin to median shaft.
19. *apache* var. *juniperus*
Dorsal aedeagus process, fig. 72, with lateral terminal projections sharp pointed and straight, abruptly narrowed anteriorly to shaft of aedeagus.
20. *alternatus*

1. *Idiocerus suturalis* Fitch

Idiocerus suturalis Fitch (1851, p. 59).

Fig. 35. Length 5.0–5.75 mm. Pale yellow, with a dark brown stripe along the suture of elytra, this sometimes interrupted, but often continuing to scutellum and pronotum. Vertex unmarked. Elytra yellowish hyaline, apexes smoky. Male antennal discs elongate, black. Female seventh sternite, fig. 79, with posterior margin rather

strongly and roundedly produced. Male plates narrow and elongate. Each style, fig. 57, tapered on anterior margin just before apex, with a single apical spine; ventral portion of aedeagus with rather long slender barbs at base of the terminal head; dorsal portion of aedeagus rounded at base and apex, constricted at middle, the apical portion gradually broadened to about three times the width of the shaft, the apical margin broadly rounded.

This species is widely distributed in the eastern United States, and ranges west to Colorado. It has been taken from willow, poplar, and birch.

Illinois Records.—APPLE RIVER CANYON STATE PARK: July 11, 1934, DeLong & Ross, 1 ♂; June 29, 1935, DeLong & Ross, 1 ♂, 2 ♀. GALENA: July 8, 1917, 1 ♀; June 20, 1932, Dozier & Mohr, 2 ♂; July 10, 1934, DeLong & Ross, 4 ♂, 5 ♀. GRAND DETOUR: July 2, 1932, Dozier & Mohr, 1 ♀. MCHENRY: July 31, 1884, 1 ♀. OAK LAWN: Aug. 24, 1933, Frison & Ross, 6 ♀. PUTNAM: July 6, 1934, Ross & DeLong, 1 ♀.

2. *Idiocerus cognatus* Fieber

Idiocerus cognatus Fieber (1868, p. 455).

Fig. 36. Length 4.5–5.0 mm. Pale, appearing faintly banded. Female usually with two small but well-defined black spots on vertex. Male with spots often faint or wanting. Face pale, with a central spot above extending on to vertex, with the small black spots either side. Pronotum pale gray with margins lighter, yellowish. Scutellum pale brown. Each elytron pale, subhyaline, veins of apical fourth brown, a brownish band at middle formed by a brownish coloration on veins. Each male antenna simple. Female seventh sternite, fig. 80, slightly but broadly and roundedly produced. Male plates elongate, narrow. Each style, fig. 58, rather broad and uniform in width throughout apical half, pointed at apex; ventral portion of aedeagus with a headlike structure, at the base of which is a pair of short barblike spines; dorsal portion of the aedeagus broadened and pointed on each lateral margin and bluntly pointed at apex.

This species has been found commonly in the eastern United States on *Populus alba*.

Illinois Record.—URBANA: Aug. 16, 1934, DeLong & Ross, 3 ♂.

3. *Idiocerus apertus* DeLong & Hershberger

Idiocerus apertus DeLong & Hershberger (1947, p. 46).

Fig. 81. Length, male 4.5 mm. In form and general appearance similar to *nervatus*, but pale brownish in color. Vertex, fig. 37, broadly rounded, a little shorter at middle than next to eyes; yellowish, tinted with brown, the central portion brownish. Disc of pronotum, basal angles of scutellum, and basal portions of elytra tinted with brown. Elytra subhyaline, with pale brownish veins. Male plates elongate, rather narrow, apices broadly rounded. Styles, fig. 59, strongly curved outwardly, apex of each bluntly pointed and bearing a pair of conspicuous spines; aedeagus with ventral portion forming a slightly enlarged apical head that has a barbed spine at base on either side; dorsal portion not quite so long as ventral and broadened at apex to form a pointed protrusion at either side and a broad slightly produced apical margin.

This species probably occurs in the southern portion of the state. It has been collected in Tennessee.

4. *Idiocerus incomptus* DeLong & Hershberger

Idiocerus incomptus DeLong & Hershberger (1947, p. 45).

Fig. 38. Length 4.5 mm. Resembling *nervatus* in form and coloration, but with distinct male genitalia. Color pale green to yellow green, without markings except pale brownish spots on basal angles of scutellum. Elytra subhyaline, with pale veins. Dark veins of under wings conspicuous from above. Face pale, slightly infuscated above. Each antennal disc slightly enlarged, elongate, black at apex. Male plates elongate, rather narrow, apices broadly rounded; each style, fig. 60, rather narrow and tapered about two-thirds of its length to form pointed apex, which bears a large spine; ventral portion of aedeagus only slightly narrowed from base to apex, the latter rounded and bearing a short spine on either side about one-fifth the distance from apex; dorsal portion of aedeagus constricted at middle, forming a rounded portion at base, which is distinctly wider than the ventral process, and also forming a smaller rounded portion just slightly wider than the ventral

process at apex; terminal rounded portion ending just anterior to spines of ventral process.

Illinois Record.—HORSESHOE LAKE: cypress, July 11, 1935, DeLong & Ross.

5. *Idiocerus nervatus* Van Duzee

Idiocerus nervatus Van Duzee (1894b, pp. 194, 205).

Fig. 39. Length 4.0–4.5 mm. Small, pale green, without dark markings on vertex. Basal angles of scutellum brown, and the brown nervures of the wings conspicuous through the pale greenish hyaline elytra. Each male antenna with small disc. Female seventh sternite, fig. 82, with posterior margin broadly truncate. Male plates long and narrow. Each style, fig. 61, gradually tapered on apical half to rather narrow apex and bearing a single prominent spine; ventral aedeagus bearing a headlike portion with a pair of very short barblike spines at base; dorsal aedeagus portion abruptly broadened at apex to form a short broad process pointed on each lateral margin and bluntly pointed at apex.

This species occurs on willows with *pallidus*, which it closely resembles. It can be distinguished by its smaller size and the dark basal angles of scutellum. It is widely distributed in the eastern United States and the Middle West and ranges west into Arizona and California.

Illinois Records.—Many males and females, taken March 24 to October 2, are from Algonquin, Alto Pass, Apple River Canyon State Park, Ashley, Carlinville, Cave in Rock, Chemung, Dongola, Fountain Bluff, Fox Lake, Geff, Gibsonia, Golconda, Havana, Herod, Horseshoe Lake, Jonesboro, Kampsville, Kankakee, Meredosia, Mount Carmel, Onarga, Oquawka, Paxton, Putnam, Quincy, Rock Island, Starved Rock State Park, Urbana, White Heath, and Zion.

6. *Idiocerus pallidus* Fitch

Idiocerus pallidus Fitch (1851, p. 59).

Bythoscopus obsoletus Walker (1851a, p. 873).

Fig. 40. Length 6.0–6.5 mm. White, tinged with green, unmarked, elytra subhyaline, nervures indistinct. Eyes reddish brown; antennal discs large. Female seventh sternite broadly and roundedly produced,

the central portion produced beyond rounded margin. Male plates slender and elongate. Each style, fig. 62, slightly narrowed on apical third, rather abruptly narrowed at apex and pointed at tip; ventral aedeagus with a slightly enlarged apical head, at the base of which is a pair of long slender spines; dorsal aedeagus rounded at base and apex and constricted at middle; apical portion only slightly wider than aedeagus shaft.

This is the common species of leafhopper on willow and poplar, and it is transcontinental in distribution.

Illinois Records.—ALGONQUIN: July 12, 1895, 1 ♂; July 19, 1895, 1 ♂; July 23, 1895, 2 ♂; July 26, 1895, 1 ♂; Aug. 12, 1895, 1 ♂; July 17, 1896, 3 ♂, 2 ♀. NIOTA: dry bog, July 28, 1936, Mohr & Burks, 1 ♀.

7. *Idiocerus duzeii* Provancher

Idiocerus duzeii Provancher (1890, p. 292).

Idiocerus perplexus Gillette & Baker (1895, p. 78).

Fig. 41. Length 6–7 mm. Resembling *pallidus*, but larger, broader, and pale yellowish green, the elytra golden iridescent, apexes fuscous. The coloration at apexes of elytra more pronounced in male than in female. Male antennal discs elongate ovate. Female seventh sternite, fig. 83, with posterior margin concavely rounded to a produced, broadly rounded median third. Male plates elongate and narrow. Each style, fig. 63, rather broad, slightly narrowed between apical portion and middle, apex abruptly narrowed to pointed tip and bearing a single spine; ventral aedeagus portion with a slightly enlarged head, which has a pair of rather long basal spines; dorsal aedeagus portion greatly enlarged at apex and angularly pointed laterally on each side and at apex.

A common species on cottonwood, *duzeii* occurs in the eastern United States and west to Colorado. It is widely distributed throughout Illinois and probably occurs wherever its host is found.

Illinois Records.—Males and females, taken June 14 to August 2, are from Alton, Cache, Elizabeth, Elizabethtown, Freeport, Galena, Grafton, Havana, Kampsville, Niota, Normal, Olive Branch, Pike, Putnam, Vienna, Volo, Wauconda, and White Heath.

8. *Idiocerus telus* DeLong & Hershberger

Idiocerus telus DeLong & Hershberger (1947, p. 45).

Fig. 42. Length 5 mm. Resembling *pallidus* in form and appearance, but differing in the male genitalia. White, tinged with green, without dark margins, basal angles of scutellum yellowish. Elytra subhyaline, veins tinted with green. Face pale. Antennal discs large, black, ovate. Male plates elongate, rather narrow. Each style, fig. 67, slightly broadened near apex, then rapidly narrowed, and bearing a prominent spine just before pointed apex; ventral portion of aedeagus tapered from base to apical fifth, which is broadened by a pair of prominent spines that are webbed to the main aedeagus shaft; these spines slope almost to a blunt apex, giving the head portion a triangular appearance; dorsal portion shorter and constricted at middle between a rather broad base and a broader diamond-shaped apex, the last with pointed apical margin, and a broad pointed lateral margin on each side.

Illinois Record.—PIKE: June 28, 1934, DeLong & Ross, 2 ♂.

9. *Idiocerus scurrus* (Germar)

Jassus scurra Germar (1834, pl. 11).

Jassus crenatus Germar (1834, pl. 10).

Idiocerus germari Fieber (1868, p. 451).

Idiocerus gemmisimulans Leonard & Crosby (1915, p. 542).

Fig. 43. Length 6–7 mm. Large, robust, brownish or brownish gray, variously marked with dark brown or black, but without definite spots on vertex. Face pale, usually with a dark, often broken, band on upper portion between eyes. In well-marked specimens the basal angles of the scutellum are black. Veins of elytra alternately yellow and brown, appearing raised and conspicuous. Central claval vein on inner margin of each elytron always yellow at apex. Seventh sternite of female roundedly produced and slightly notched at middle. Male plates narrow and elongate. Each style, fig. 68, somewhat narrowed on apical third, without long apical spine; ventral portion of aedeagus bearing a pair of long spines one-third the distance from apex, not enlarged at apex; dorsal portion of aedeagus tapered toward apex, then constricted, beyond which it is enlarged to form a large rounded apical portion.

This European species, which has been recorded from New York, has been taken from Lombardy poplar.

Illinois Record.—URBANA: Sept. 1-9, 1944, Hasbrouck, 1 ♀.

10. *Idiocerus hebetus* DeLong & Hershberger

Idiocerus hebetus DeLong & Hershberger (1947, p. 48).

Fig. 44. Length 6-7 mm. Resembling *lachrymalis* Fitch (1851, p. 58) in form and appearance, but paler in color and with distinctive male genitalia. Face pale, ocelli dark. A broken dark brown band on margin of vertex forming a dark spot next to each eye, and a band produced upward on each end to include a round spot like that on *lachrymalis*. Pronotum cream to dark gray, median anterior portion pale brown. Scutellum white to cream; basal angles brown, a transverse line at middle brown. Each elytron brownish subhyaline, darker on anterior half of clavus and apical portion. Male antennal discs narrow, elongate, black. Male plates elongate and rather narrow. Styles, fig. 66, each rather broad and only slightly tapered to region near apex, then pointed and bearing a prominent spine; ventral portion of aedeagus stout, with a pair of rather long basally directed spines just before apex; dorsal portion of aedeagus broader at base than ventral portion, narrowed, then broadened at apex to form a diamond-shaped tip with a pointed apex, lateral margins sharply angled.

This species can easily be distinguished from *lachrymalis*, a western species which has been confused with it in the past, by the paler, more uniform color, the smaller diamond-shaped terminus of the dorsal aedeagus, and the single instead of double spines at apex of each style. For purposes of comparison, *lachrymalis* is illustrated in figs. 45, 65, 84.

Illinois Records.—GALENA: July 10, 1934, DeLong & Ross, 2 ♂, 3 ♀; June 28, 1935, DeLong & Ross, 1 ♂.

11. *Idiocerus subnitens* Sanders & DeLong

Idiocerus subnitens Sanders & DeLong (1917, p. 82).

Fig. 53. Length 6 mm. Resembling *lachrymalis* in coloration but smaller and nar-

rower. Vertex with broad black band between eyes and with round black spot either side above band and not far from eyes. Pronotum with dark markings, especially noticeable at lateral margins. Scutellum with black basal angles, a central Y-shaped black line with the bifurcate portion at apex, and a round black spot at either side on disc; each elytron smoky, nervures brown except for a white transverse band at apex of clavus. Female seventh sternite with posterior margin roundedly produced. Male plates narrow, elongate. Styles, fig. 64, tapered and narrowed on apical third, each bearing two long prominent spines at apex; ventral portion of aedeagus with an elongate rather narrow head portion bearing a pair of rather short spines at base; dorsal aedeagus portion broadened, fanlike at apex, considerably wider than aedeagus shaft, and with a broadly rounded apex.

This species has been taken only in small numbers from poplar in the more northern regions of the eastern United States. It has not been recorded from Illinois but is known to occur in Wisconsin.

12. *Idiocerus ramentosus* (Uhler)

Bythoscopus ramentosus Uhler (1877, p. 465).

Idiocerus mimicus Gillette & Baker (1895, p. 76).

Idiocerus brunneus Osborn & Ball (1898, pp. 72, 129).

Fig. 47. Length 4-5 mm. Broad, robust, cinnamon brown in color, with two black spots margined with yellow on vertex; an interrupted line below spots. Face tawny. Pronotum and scutellum brown. Elytra brown, subhyaline, nervures dark brown, tuberculate. Male antennal discs slightly elongate. Female seventh sternite, fig. 85, with posterior margin broadly and roundedly produced. Male plates elongate and narrow. Styles, fig. 69, rather narrow, each broadest at about one-fourth of the distance from apex, which is bluntly pointed and without long spines; ventral aedeagus slightly enlarged at apex, with a pair of long spines at base of enlargement and not far from apex; dorsal aedeagus rounded at base, narrowed to a slender shaft, which is not enlarged at apex.

This is one of the willow species occurring in the Mississippi River valley and westward to Colorado.

Illinois Records.—Males and females, taken May 6 to October 1, are from Alton,

Byron, Elizabethtown, Fulton, Grafton, Havana, Homer, Kampsville, Lima, Meredosia, Pike, Putnam, Quincy, Rock Island, Savanna, Seymour, and Topeka.

13. *Idiocerus crataegi* Van Duzee

Idiocerus crataegi Van Duzee (1890b, p. 110).

Fig. 48. Length 4.75–5.25 mm. Gray, with a pair of black spots on anterior margin of vertex, on pronotum, and on scutellum, these three pairs of spots arranged in two longitudinal rows; in addition, a pair of small approximate spots on disc of scutellum, a pair beneath ocelli, and a more elongate pair beneath the antennae. Elytra greenish brown, nervures dark. Female seventh sternite almost triangular, apex slightly and angularly notched. Male plates narrow and elongate. Each style, fig. 70, uniform in width on apical two-thirds and blunt at apex; ventral portion of aedeagus slender, scarcely enlarged at apex and bearing a pair of prominent spines near apex; dorsal aedeagus process broadened to about twice its width at apex; lateral portions angled and sharply pointed and apex pointed.

Recorded from Iowa, Missouri, and Colorado, *crataegi* is one of the common species on various types of *Crataegus*.

Illinois Records.—MONTICELLO: Sept. 22, 1934, Ross, 2 ♀. URBANA: July 9, 1920, 1 ♀; Sept. 6, 1934, DeLong and Ross, 2 ♂, 10 ♀.

14. *Idiocerus provancheri* Van Duzee

Bythoscopus clitellarius Provancher (1890, p. 288). Name preoccupied.

Idiocerus provancheri Van Duzee (1890b, p. 111). New name.

Fig. 49. Length 5.0–5.3 mm. Fulvous brown in color, with a broad yellow stripe on clavus. Vertex with two large black spots. Pronotum with pale spots only. Scutellum rufous. Costal margin of each elytron with hyaline spot before tip, a distinct bright yellow area from basal outer claval margin to just before apex of outer claval nervure. Female seventh sternite, fig. 86, rather strongly and roundedly produced on posterior margin. Male plates elongate and narrow. Styles, fig. 73, strongly curved on apical third and each tapered to pointed apex; ventral portion of aedeagus constricted about one-third the distance from the apex and then slightly enlarged and blunt at apex;

ventral aedeagus enlarged at apex to form a broad fanlike structure, which is broadly and convexly rounded on apical margin.

Like *crataegi*, *provancheri* is common on *Crataegus* throughout the eastern United States.

Illinois Record.—MONTICELLO: June 11, 1934, Frison & DeLong, 3 ♂, 2 ♀.

15. *Idiocerus fitchi* Van Duzee

Idiocerus maculipennis Fitch (1851, p. 59). Name preoccupied.

Idiocerus fitchi Van Duzee (1909b, p. 383). New name.

Fig. 50. Length 5.25–5.75 mm. Brown, with narrow stripes on pronotum, scutellum, and clavus. Vertex with a pair of large black spots surrounded by broad yellow circles. Small crescents under the ocelli light yellow. Pronotum with a pair of black spots on the anterior margin; three spots on disc and posterior margin yellow. Scutellum with apex and margins pale yellow. Elytra brown, nervures darker, each elytron with a narrow light stripe on outer margin of clavus; costal margin broad and dark, interrupted by a hyaline band that crosses the apex and broadens on costa. Each antenna simple. Female seventh sternite, fig. 89, with posterior margin broadly and roundedly produced. Male plates elongate and narrow. Styles, fig. 76, together lyrate in shape, narrowed on apical halves, curved outwardly and gradually narrowed to pointed apices; ventral aedeagus narrowed on middle half, apical portion clublike and rounded at apex.

An abundant species on *Crataegus* and often found on cultivated varieties of apple, *fitchi* occurs in the eastern United States and west to Iowa.

Illinois Records.—LUDLOW: Aug. 19, 1914, 1 ♀. MONTICELLO: June 11, 1934, Frison & DeLong, 4 ♂, 7 ♀. MUNCIE: July 5, 1914, 1 ♀. PROPHETSTOWN: July 7, 1925, T. H. Frison, 1 ♀. SHAWNEETOWN: June 14, 1934, Ross & DeLong, 1 ♂. URBANA: June 29, 1891, Hart & McElfresh, 1 ♂; July 5, 1891, Shiga, 1 ♂; June 23, 1892, Summers, 1 ♀; June 24, 1892, McElfresh, 1 ♂; June 25, 1892, 1 ♀; June 28, 1892, McElfresh, 1 ♀; Aug. 19, 1892, Hart, 2 ♀; Sept. 17, 1892, 1 ♀; July 9, 1920, 4 ♀; July 26, 1920, 1 ♀; Sept. 6, 1934, DeLong & Ross, 3 ♀. WHITE HEATH: July 5, 1916, 1 ♂, 2 ♀.

16. *Idiocerus snowi* Gillette & Baker

Idiocerus snowi Gillette & Baker (1895, p. 79).

Fig. 55. Length 5.25–5.75. Pale green, with two small round black spots on vertex and elytra, suture black. Face yellow, pronotum and scutellum unmarked. Elytra yellowish green, each with a dark brown stripe along the sutural margin from the apex of scutellum to the apex of clavus. Male antennae simple and without discs. Female seventh sternite, fig. 88, with posterior border convexly rounded, shallowly emarginate on median half. Male plates elongate and narrow. Each style, fig. 71, broad, apical fifth gradually narrowed to bluntly pointed apex, without long spines at apex; ventral aedeagus broad at base, narrowed and produced to form a long slender apical portion, with lateral spines almost half way from apex to base; dorsal process of aedeagus broad from base to apex and broadened on apical third to form a pointed lateral margin on each side; apical margin broad, slightly produced at middle and broadly pointed.

This species occurs on narrow-leaved willows and is common in the middle western states.

Illinois Records.—Many males and females, taken June 13 to September 27, are from Algonquin, Alton, Alto Pass, Apple River Canyon State Park, Arcola, Beardstown, Byron, Champaign, Chemung, Danville, Decatur, Des Plaines, Eichorn, Elizabethtown, Fox Lake, Fulton, Grafton, Grand Tower, Havana, Kampsville, Kankakee, Lawrenceville, Mason City, Mokence, Neoga, Niota, Normal, Oak Lawn, Ogden, Oquawka, Ottawa, Pike, Princeton, Prophetstown, Putnam, Rock Island, St. Anne, Savanna, Seymour, Shawneetown, Starved Rock State Park, Topeka, Urbana, and Waukegan.

17. *Idiocerus rotundens* DeLong & Caldwell

Idiocerus rotundens DeLong & Caldwell (1937, p. 162).

Fig. 52. Length 4.5–6.0 mm. Pale yellow, with black ocelli. Vertex with a round median dusky area and a round black spot on either side. Scutellum marked only by black spots at base. Elytra white, veins to pical crossveins white, brownish beyond pical crossveins. Each antenna with large

circular terminal black disc. Female seventh sternite almost truncate on posterior margin, slightly produced, broadly rounded. Male plates narrow and elongate. Each style, fig. 74, slightly and gradually narrowed to pointed apex, bearing a single long spine; ventral aedeagus slender to apex, bearing a pair of prominent spines about one-fourth the distance from apex; dorsal portion of aedeagus enlarged at apex to form a rather broad process, the lateral margins of which are pointed, the posterior margin gradually sloping to the median two-thirds, which is truncate apically.

This is one of the small species occurring on willow. It has previously been recorded in the literature only from Wisconsin.

Illinois Records.—Many males and females, taken May 6 to October 31, are from Algonquin, Antioch, Ashley, Byron, Centerville, Champaign, Crescent City, Danville, Fox Lake, Freeport, Fulton, Grafton, Grand Tower, Grays Lake, Havana, Homer, Kampsville, Kankakee, Meredosia, Metropolis, New Holland, Niota, Oak Lawn, Oregon, Pike, Princeton, Putnam, Quincy, Rock Island, Seymour, Spring Grove, Waukegan, and Vienna.

18. *Idiocerus varius* DeLong & Hershberger

Idiocerus varius DeLong & Hershberger (1947, p. 46).

Fig. 46. Length 5.0–5.5 mm. Resembling *alternatus* in general coloration and appearance, but with distinctive male genitalia and large antennal discs. Face marked as in *alternatus*, with a large median dark area on upper portion extending across vertex. Vertex marked with an elongate brown spot next to each eye and a large round black spot not far from each eye just above margin. Pronotum brown, with heavy dark markings. Scutellum pale brown, with black spots in basal angles and a series of small connected black spots across middle. Elytra pale brownish subhyaline, veins dark brown, interrupted by white veins at the middle of each clavus and across elytron at apex of clavus. Male antennal discs broad, ovate, and black.

Female seventh sternite, fig. 87, slightly and roundedly produced posteriorly. Male plates elongate and narrow. Each style, fig. 77, long and slender and with a spine near apex; ventral portion of aedeagus rather

broad at base and tapered to form a rather narrowed head with a barblike spine either side about one-fourth the distance from apex; dorsal portion of aedeagus broad at base, constricted on median portion and narrow to apex, which is broadened to the width of the projecting spines on ventral portion; apex convexly rounded.

Illinois Records.—Many males and females, taken June 14 to July 16, are from Algonquin, Apple River Canyon State Park, Geff, Golconda, Grand Detour (Castle Rock), Karnak, Rock Island, Shawneetown, and Vienna.

19. *Idiocerus apache* var. *juniperus*
DeLong & Hershberger

Idiocerus apache var. *juniperus* DeLong & Hershberger (1947, p. 46).

Fig. 54. Length 4.5–5.0 mm. Resembling *alternatus* in form and general appearance, but with larger antennal discs and distinctive genitalia. Face pale, lorae and genae with heavy brown longitudinal stripes. Upper portion of face with a large median dark area that extends across vertex as in *alternatus*. Vertex pale brown, with a round black spot on each side not far from eye and just above margin. Pronotum pale brown, tinted with gray and with dark brown markings on anterior portion. Scutellum cream to pale brown, black spots in basal angles and a broad longitudinal white stripe on apical half. Elytra brownish subhyaline, veins dark brown, interrupted by white portions at middle of each clavus and apex of clavus. Male antennal discs black, elongate, ovate. Female seventh sternite, fig. 90, scarcely produced posteriorly, almost truncate. Male plates elongate, rather narrow. Styles, fig. 75, tapered, apical half of each rather slender, bearing a pair of spines near apex on dorsal portion; ventral portion of aedeagus rather straight and slender, with a pair of short barblike spines a short distance from apex; dorsal portion of aedeagus broadened gradually, then abruptly to form a broad apex, which is slightly trilobate on apical margin and has broad but pointed lateral processes.

The typical *apache* Ball & Parker (1946, p. 76) is a western form, occurring in Arizona, Utah, and California.

Illinois Records.—GOLCONDA: June 22, 1932, Ross, Dozier, & Park, 1♀, 2♂. HORSESHOE LAKE: July 11, 1935, DeLong

& Ross, 1♂. KAMPSVILLE: June 27, 1934, DeLong & Ross, 1♂, 3♀. MAHOMET: April 30, 1936, Frison & Ross, 1♂. URBANA: April 6, 1900, 1♂.

20. *Idiocerus alternatus* Fitch

Idiocerus alternatus Fitch (1851, p. 59).
Idiocerus interruptus Gillette & Baker (1895, p. 74).

Fig. 56. Length 5.0–5.25 mm. Brownish fuscous, marked with white on pronotum and elytra. Vertex usually marked with a brownish crescent outside the round spots. A light stripe on the middle of pronotum extending on to vertex and back across the scutellum. Basal angles and two spots on disc of scutellum black. Elytra subhyaline, nervures fuscous, interrupted with white, a large circular light spot covering the tips of the outer claval nervures and a smaller one at apex of each clavus. Male antennal discs black, slightly enlarged. Female seventh sternite slightly produced, almost truncate, slightly notched at middle. Male plates elongate and narrow; styles, fig. 72, gradually tapered to narrow pointed apices, each of which bears a pair of long spines; ventral aedeagus narrow and bearing a small short headlike structure at the base of which is a pair of short barblike spines; dorsal process of aedeagus abruptly broadened to form a transverse apical process, each lateral margin of which is sharp pointed; the apical margin curves convexly between the pointed lateral margins.

Transcontinental in distribution, this is one of the most abundant species occurring on willow.

Illinois Records.—APPLE RIVER CANYON STATE PARK: Aug. 22, 1935, DeLong & Ross, 1♀; July 16, 1936, Mohr, 2♂, 1♀. GEFF: June 12, 1934, DeLong & Ross, 1♂, 2♀. GRAND DETOUR: Castle Rock, July 12, 1934, DeLong & Mohr, 1♂. HAVANA: July 2, 1934, DeLong & Mohr, 2♂; Aug. 30, 1917, 1♂. ST. JOSEPH: May 10, 1914, 1♂. URBANA: April 4, 1889, Marten, 2♂; April 4, 1908, 3♂, 1♀.

21. *Idiocerus moniliferae* Osborn
& Ball

Idiocerus moniliferae Osborn & Ball (1898, pp. 71, 131).

Fig. 51. Length 5.5 mm. Resembling *alternatus* in coloration but a little larger.

more robust, and more distinctly marked. Margin of vertex marked with a broad transverse band between ocelli and spots on vertex. Front broad, a brown band on either side just inside anterior margin extending across just below the antennal pits. Elytra subhyaline, nervures alternately light and dark, bases of all nervures light, the cross nervures between the sectors broadly light. Each antenna simple and without disc. Female seventh sternite, fig. 91, rather strongly and roundedly produced. Male plates long and slender. Each style, fig. 78, especially broadened on apical half, apex pointed; ventral portion of aedeagus slender and produced apically; dorsal portion slightly and abruptly broadened near apex, forming an apical triangular head, the apex of which is bluntly pointed.

This species has previously been recorded from Iowa and Kansas.

Illinois Records.—KARNAK: June 23, 1932, Ross, Dozier, & Park, 1 ♀. LITCHFIELD: May 10, 1932, Ross & Mohr, 1 ♂. LUTHER: dry marsh, July 2, 1934, DeLong & Ross, 1 ♀. OAKWOOD: May 15, 1926, Auden, 1 ♀. URBANA: Aug. 6, 1890, at light, Hart & Shiga, 1 ♂.

Subfamily MACROPSINAE

The vertex is short but is obtusely angled anteriorly. The hind wing has three apical cells.

Two genera belong to this subfamily, *Macropsis* and *Oncopsis*, both of which occur in Illinois.

KEY TO GENERA

- Ocelli about midway between eyes and meson, fig. 93. 2. *Macropsis*
- Ocelli about twice as far from meson as from eyes, fig. 92. 3. *Oncopsis*

2. *MACROPSIS* Lewis

Macropsis Lewis (1835, p. 49).
Pediopsis Burmeister (1838, pl. 10).

Figs. 26, 93, 94. Head almost or entirely deflexed, as wide as pronotum; vertex almost parallel margined, obtusely angulate. Lorae of female prominent, tumid; those of male often reduced and nearly obscured by the swollen and bulging clypeus. Pronotum distinctly angled anteriorly, produced beyond the anterior margins of the eyes; lateral margins very short, posterior margin

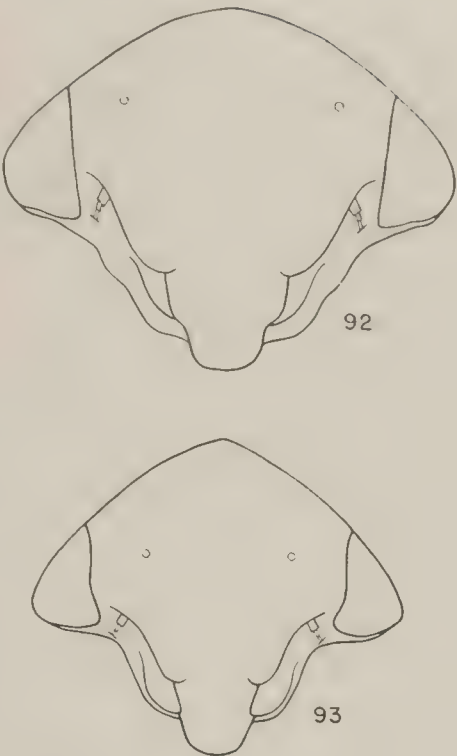


Fig. 92.—*Oncopsis viridis* ♀, face.
Fig. 93.—*Macropsis basalis* ♀, face.

usually broadly concave and in some species somewhat angulate; striae or rugae radiating from a central line obliquely toward the posterior angles. Elytra without appendixes.

These species occur for the most part upon willow, poplar, honey locust, and wild plum, and are frequently found in association with species of *Idiocerus*, which are found on at least two of the same trees or shrubs. The genus, which is distributed throughout the United States and Canada, contains nearly 40 species and varieties, of which 17 have been taken in Illinois. Two others may occur here.

The following key to species is condensed largely from that of Breakey (1932).

KEY TO SPECIES

- 1. Green in color; each hind tibia usually bearing a prominent black spot near the base; a black spot at apex of vertex. 1. *virescens* var. *graminea*
Hind tibiae without black spots. 2
- 2. Flytra of a uniform color (color of underlying body must not be considered). 3
Elytra not of the same color or shade throughout 17

3. Elytra green or greenish hyaline, sometimes slightly smoky. 4
Elytra amber to smoky amber. 14
 4. Prothoracic epimeron bearing a distinct black spot behind the eye. 5
Prothoracic epimeron unmarked. 8
 5. Female. **2. erythrocephala**
Male. 6
 6. Extremities of tibiae banded with black. 7
Extremities of tibiae not banded with black (western). **2. erythrocephala**
 7. Length 5 mm., face not marked with black. **3. trivialis**
Length 4 mm., face with definite black markings. **4. reversalis**
 8. Females. 9
Males. 13
 9. More than 5 mm. in length. 10
Not exceeding 5 mm. in length. 12
 10. Body concolorous with elytra. 11
Head and thorax reddish brown, elytra pale green. **5. rufocephala**
 11. Robust in form; clypeus tumid, keystone shaped. **6. viridis**
More slender in form; clypeus not so tumid, lateral margins more nearly parallel. **3. trivialis**
 12. Clypeus nearly parallel margined; elytra smoky, especially on the clavus. **15. fumipennis** var. **gleditschiae**
Clypeus definitely keystone shaped; elytra faintly smoky apically. **7. confusa**
 13. Robust in form; face long; smokiness of elytra concentrated on claval areas. **15. fumipennis** var. **gleditschiae**
Slender; face short; smokiness of elytra wanting or limited to apical areas. **7. confusa**
 14. Vertex and pronotum green to yellowish green, not spotted; abdomen fulvous. **6. viridis**
Vertex, pronotum, and abdomen otherwise. 15
 15. Anterior impressions concolorous with pronotum. **8. basalis**
Anterior impressions darkly maculate with fuscous. 16
 16. Pronotum obtusely angled anteriorly; lateral margins of clypeus bulging out over the lorae. **9. bifasciata**
Pronotum right angled anteriorly; lateral margins of clypeus nearly parallel, distinct. **2. erythrocephala**
 17. Face with conspicuous impressed black points or spotted with black. **10. tristis**
Face without points or spots, sometimes suffused with fuscous. 18
 18. Elytra hyaline with well-defined and nearly continuous transverse fuscous bands. 19
Elytra otherwise. 22
 19. Bases of elytra heavily banded with deep brownish fuscous. 20
Bases of elytra free of brownish or fuscous bands. 21
 20. Head and thorax concolorous with rest of body. **12. osborni**
Head and thorax reddish brown above in contrast with greenish body. **8. basalis**
 21. Elytra narrowly twice banded with fuscous, anterior band oblique, interrupted at claval suture. **9. bifasciata**
Elytra broadly twice banded with fuscous, anterior band transverse, not interrupted at claval suture. **11. canadensis**
 22. Elytra marked with black or deep fuscous in the form of patterns or definite areas. 23
Elytra deep brownish opaque, marked with a transverse hyaline band or pellucid white spots. 24
 23. Clavus black; corium of female green, corium of male smoky amber. **13. suturalis**
Black or fuscous color of elytra extending to near costa, costa green or greenish hyaline. **14. fumipennis**
 24. Elytra deep brownish opaque, a transverse band before the apex. 25
Elytra brownish opaque, unmarked, or marked with round pellucid white spots. 26
 25. Elytra uniform ferruginous brown, hyaline band narrow. **16. ferruginoides**
Elytra blackish, hyaline band usually indefinite; black in base of each elytron often confined to corium and concentrated along costa. **17. nigricans**
 26. Brownish, one pellucid white spot on each corium of female and sometimes of male; clavus concolorous with corium. **18. insignis**
Blackish brown, three pellucid white spots on each corium; clavus cinereous. **19. trimaculata**
1. *Macropsis virescens* var. *graminea* (Fabricius)
- Cicada graminea* Fabricius (1798, p. 521).
- Length of female 5.0 mm., male 4.4 mm. Slender, green, with vertex rather sharply pointed. Each hind tibia of both sexes bears a conspicuous black spot on the outside near the base. The face appears almost flat as viewed from the sides. The female is yellowish green, with a black spot at apex of vertex. The male is frequently infuscated above. Elytra greenish hyaline with apex smoky and veins green. Basal angles of scutellum in both sexes usually infuscated. Epimera marked with black spots.
- This variety of the species *virescens* Gmelin (1790, p. 2111) has been collected from the poplar, *Populus nigra*. It has been recorded from the eastern states and as far west as Wisconsin and Illinois.
- Illinois Records.**—ALDRIDGE: May 8, 1932, Dozier, 3♂, 1♀. DUBOIS: May 24, 1917, 1♀. ELIZABETHTOWN: May 27-31, 1932, Dozier, 3♂, 3♀. GRAND TOWER: May 12, 1932, Frison, Ross, & Mohr, 1♂. KAMPSVILLE: June 27, 1934, DeLong &

Ross, 1 ♀. MOUND CITY: May 24, 1932, Dozier, 1 ♀. ROUND LAKE: June 27, 1936, Frison & DeLong, 25 ♂, 63 ♀. ULLIN: May 26, 1932, Dozier, 1 ♀.

2. *Macropsis erythrocephala* (Gillette & Baker)

Pediopsis erythrocephala Gillette & Baker (1895, p. 72).

Length of female 6 mm., male 5 mm. Dimorphic color. Female green, slightly tinted with fulvous anteriorly. Elytra pale greenish hyaline. Male brown to brownish green, heavily marked with fuscous. Face and area beneath fuscous, pronotum and scutellum brown, the basal angles of scutellum with black triangular spots. Elytra fuscous hyaline, veins darker. A large black spot on each epimeron in both sexes. Face distinctly concave as viewed from the side.

Commonly found on willow, *Salix longifolia*, this species has been collected from coast to coast, and is especially numerous in the northern states.

Illinois Records.—Many males and females, taken June 12 to August 24, are from Alton, Beardstown, Byron, Cache, Carbondale, Decatur, Eichorn, Elizabethtown, Fox Lake, Freeport, Galena, Geff, Grafton, Grand Detour, Grand Tower, Havana, Kampsville, Kankakee, Marshall, New Milford, Newton, Oquawka, Oregon, Palos Park, Pike, Prophetstown, Putnam, Savanna, Spring Grove, Spring Valley, Urbana, Vienna, Waukegan, and West Union.

3. *Macropsis trivialis* (Ball)

Pediopsis trivialis Ball (1902b, p. 304).

Length of female 5.5 mm., male 4.5 mm. More slender in form than *viridis*. Female yellowish green, unmarked, elytra greenish hyaline with concolorous veins. Male with black spots on the epimera, extremities of the fore and middle tibiae, and tarsal claws; elytra greenish hyaline, somewhat smoky toward the apexes. In both sexes the second apical cell is usually more than half the length of the middle anteapical cell.

Taken from willow, *Salix amygdaloides*, this species is known to occur in the eastern United States and as far west as Colorado.

Illinois Records.—ELIZABETH: July 8, 1917, 1 ♀. FREEPORT: July 2, 1917, 1 ♂, 3 ♀. GALENA: July 5, 1917, 1 ♂. GEFF: June 12, 1934, DeLong & Ross, 1 ♀. HOMER:

June 4, 1916, 1 ♀. MONTICELLO: June 11, 1934, Frison & DeLong, 1 ♂, 3 ♀. PUTNAM: July 6, 1934, Ross & DeLong, 6 ♀. URBANA: June 19, 1889, Hart, 1 ♀; June 28, 1892, McElfresh, 1 ♂. WHITE HEATH: July 5, 1916, 1 ♀.

4. *Macropsis reversalis* (Osborn & Ball)

Pediopsis reversalis Osborn & Ball (1898, pp. 69, 123).

Length of female 4.5 mm., male 4.0 mm. Small and greenish. The female is unmarked, while the male has on the face two broad black bands, sometimes broken into spots, and black spots on the epimera and extremities of the legs. In some individuals the bands on the face are reduced to three spots, one on the apex above, and one just within and below each ocellus. Face somewhat tumid as viewed from the side. Elytra greenish hyaline.

This species has been taken from *Salix* spp. in the eastern United States.

Illinois Records.—Males and females, taken May 29 to July 16, are from Apple River Canyon State Park, Fulton, Galena, Grafton, Grand Detour, Havana, Herod, Lacon, Meredosia, Oquawka, Oregon, Pike, Putnam, Rock Island, and Urbana.

5. *Macropsis ruficeps* Osborn

Macropsis scutellatus Osborn (1928, p. 218). Name preoccupied.

Macropsis ruficeps Osborn (1932, p. 513). New name.

Length of female 5.5 mm. Yellowish green. Female with vertex, pronotum, anterior two-thirds of scutellum, and upper half of face reddish brown. Scutellum with black spots in basal angles, apical angle yellowish green. Elytra pale greenish hyaline, veins green. Epimera unmarked. Face appearing concave below vertex as viewed from the side. No male has been collected.

This is a transcontinental species and has been collected from willow, *Salix* spp.

Illinois Records.—FREEPORT: July 2, 1917, 1 ♀; July 4, 1917, 1 ♀. HOMER: June 14, 1916, 1 ♀.

6. *Macropsis viridis* (Fitch)

Pediopsis viridis Fitch (1851, p. 59).

Length of female 5.5 mm., male 4.5 mm. Robust, yellowish green. Female unmarked,

elytra greenish hyaline, veins green. Male elytra amber-brown, veins concolorous; each epimeron bears a broad black mark and abdomen is fulvous above. In both sexes face appears almost flat as viewed from the side. Elytra each with the second apical cell scarcely more than half as long as the middle anteapical cell.

This is a widely distributed northern transcontinental species that has been reported feeding upon willow, *Salix longifolia*.

Illinois Records.—Many males and females, taken May 12 to August 8, are from Algonquin, Apple River Canyon State Park, Alton, Champaign, Danville, Decatur, Eichorn, Elizabethtown, Fox Lake, Freeport, Fulton, Galena, Geff, Grafton, Grand Detour, Grand Tower, Grays Lake, Hardin, Havana, Herod, Iroquois, Kampsville, Lacon, Marshall, Meredosia, Monticello, New Holland, Newton, Oquawka, Oregon, Pike, Princeton, Putnam, Quincy, Round Lake, Savanna, Shawneetown, Spring Valley, Temple Hill, Urbana, Vienna, Wauconda, West Union, White Heath, and Zion.

7. *Macropsis confusa* Breakey

Macropsis confusa Breakey (1932, p. 827).

Length of female 4.75 mm., male 4.0 mm. Pale green, resembling *viridis* but smaller; without definite markings. Elytra faintly smoky. Face appearing distinctly tumid as viewed from the side. Epimera in both sexes without spots.

The species is known to occur on poplar, *Populus* spp., and has been taken in the northeastern states and in Wisconsin, as well as Illinois.

Illinois Records.—ANTIOCH: June 12, 1926, Ross & Burks, 16♂, 3♀; Aug. 1, 1930, Frison, Knight, & Ross, 1♀. DUBOIS: May 24, 1917, 1♂, 1♀. ELIZABETHTOWN: May 21–31, 1931, Dozier, 1♂. GALENA: June 28, 1935, DeLong & Ross, 15♀. HARDIN: June 5–9, 1932, Dozier, 1♀. KAMPVILLE: June 27, 1934, DeLong & Ross, 1♀. NEW HOLLAND: June 5, 1936, Mohr & Burks, 1♂. SAVANNA: July 27, 1892, McElfresh, Shiga, Hart, & Forbes, 1♂.

8. *Macropsis basalis* (Van Duzee)

Pediopsis basalis Van Duzee (1889b, p. 171).

Length of female 5.0 mm., male 4.0–4.25 mm. Robust, dark transverse bands on the

elytra. Epimera unmarked in the female, with black spots in the male. Female olive green; pronotum, scutellum, and upper portion of face ferruginous; elytra greenish hyaline, a broad black band on the base of each clavus and two other transverse bands sometimes fused. Male smoky ferruginous; elytra dark amber, with black basal bands as in female; vertex, pronotum, and scutellum with brown punctures; brown triangular spots in basal angles of scutellum.

This species, northern in range, occurs upon quaking aspen, *Populus tremuloides*.

Illinois Records.—APPLE RIVER CANYON STATE PARK: June 29, 1935, DeLong & Ross, 7♂, 33♀. GALENA: on aspen, July 10, 1934, DeLong & Ross, 3♂, 6♀; June 28, 1935, DeLong & Ross, 20♂, 19♀. GRAFTON: along river, June 26, 1934, DeLong & Ross, 1♀. SPRING GROVE: June 8, 1938, Burks & Mohr, 1♀. WARREN: June 29, 1935, DeLong & Ross, 2♂, 5♀.

9. *Macropsis bifasciata* (Van Duzee)

Pediopsis bifasciata Van Duzee (1889b, p. 173).

Length of female 5.25 mm., male 5.0 mm. Dull greenish ferruginous, marked by two dark transverse cross bands. Pronotum washed with fuscous on disc. Face pale yellow. Basal angles of scutellum with black triangular spots. Female with elytra grayish hyaline, an oblique transverse band across middle of each, interrupted at claval suture, and another transverse band just below the apex; veins concolorous. Male with elytra fuscous hyaline, without bands. Epimera of both sexes with large black spots.

This species has been collected from poplar, *Populus* spp., and ranges from the eastern United States to Colorado.

Illinois Records.—GALENA: July 10, 1934, DeLong & Ross, 2♀; June 28, 1935, DeLong & Ross, 1♀.

10. *Macropsis tristis* (Van Duzee)

Pediopsis tristis Van Duzee (1890b, p. 249).

Length of female 5.5 mm., male 4.75 mm. Cinereous brown, pale beneath. Pronotum and scutellum cinereous. Basal angles of scutellum with black triangular spots. Face with black band above and large circular black spot below. Elytra cinereous hyaline, veins lighter, narrowly margined with fuscous. Epimera slightly fuscous.

This species ranges from the East to the Middle West and is known to occur on wild plum, *Prunus* spp.

Illinois Record.—NORTHERN ILLINOIS: June, Peabody Collection, 2 ♀.

11. *Macropsis canadensis* (Van Duzee)

Pediopsis canadensis Van Duzee (1890b, p. 111).

Length of female 5.25 mm., male 4.75 mm. Varying from pale yellowish green to pale fulvous, the elytra with two brown bands. Pronotum obtusely angled, moderately convex; elytra long, rather narrow, broadly rounded at apex.

Female head and thorax yellowish green or greenish fulvous, immaculate, epimera unmarked; elytra greenish hyaline, each with two brownish fulvous bands, the first near the middle and the second just before the apex. Male darker, fulvous or tawny, each epimeron bearing a large black spot; lower part of face and area beneath paler; scutellum cinereous, a brown triangle within each basal angle, a narrow red line down the center to the transverse impression, which is also reddened; elytra banded as in female.

This species is widely distributed from Maine to California. It should be found in northern Illinois.

12. *Macropsis osborni* Breakey

Macropsis osborni Breakey (1932, p. 817).

Length of female 6 mm., male 5 mm. Superficially resembling *basalis*, especially in having a dark band across base of elytra. Face appears tumid as viewed from the side. Female yellowish green, elytra greenish hyaline, with a cupreous tint, a broad black band confined to the bases of the claval areas bordering scutellum; epimera without spots. Male green, washed with fuscous; elytra cinereous hyaline, tinged with fulvous, a broad black band on bases of elytra as in female; basal angles of scutellum with large triangular spots; epimera with black spots.

This species has been taken only in the middle western states, where it occurs in small numbers on cottonwood, *Populus deltoides*.

Illinois Records.—KAMPSVILLE: June 27, 1934, DeLong & Ross, 1 ♀. PIKE: June 28, 1934, DeLong & Ross, 1 ♀. SHAWNEETOWN: June 14, 1934, Ross & DeLong, 3 ♀.

13. *Macropsis suturalis* (Osborn & Ball)

Pediopsis suturalis Osborn & Ball (1898, pp. 67, 119).

Length of female 5.5 mm., male 5.0 mm. Female green, with entire clavus black. Male sordid green, elytron smoky so that the black clavus is less conspicuous than in female; scutellum sordid green on the disc, each basal angle marked with a black triangle; pronotum and vertex marked with fuscous; epimera each bearing a black dash.

This species has been reported as occurring on willow, *Salix amygdaloides*. It is known to occur in Iowa, Kansas, Minnesota, Wisconsin, Ohio, Pennsylvania, and Maine, and it probably occurs in Illinois.

14. *Macropsis fumipennis* (Gillette & Baker)

Pediopsis fumipennis Gillette & Baker (1895, p. 73).

Pediopsis crocea Osborn & Ball (1898, pp. 68, 120).

Length of female 4.75 mm., male 4.0–4.25 mm. Green, heavily tinged with smoky brown. Pronotum yellowish green, disc fuscous. Basal angles of scutellum each with black triangular spots and with two large round impressed green or yellow spots just before the anterior impression. Elytra black or dark brown opaque, costal margins green or yellowish. Epimera without spots.

This species has been taken from honey locust, *Gleditsia triacanthos*, and is recorded from Montana, Colorado, Kentucky, and Ohio, as well as Illinois.

Illinois Records.—ELIZABETHTOWN: May 27–31, 1931, Dozier, 1 ♂. HAVANA: June 14, 1934, DeLong & Ross, 1 ♂. IROQUOIS: June 5, 1932, Frison & Mohr, 2 ♂. MONTICELLO: June 11, 1934, Frison & DeLong, 1 ♂. MUNCIE: June 8, 1917, 1 ♂. ST. ANNE: July 20, 1934, DeLong & Ross, 1 ♀. SHAWNEETOWN: June 27, 1936, DeLong & Mohr, 2 ♀. URBANA: June 19, 1889, Hart, 1 ♂. VOLO: in bog, June 11, 1936, Ross & Burks, 1 ♂.

15. *Macropsis fumipennis* var. *gleditschiae* (Osborn & Ball)

Pediopsis gleditschiae Osborn & Ball (1898, pp. 67, 122).

Length of female 4.75 mm., male 4.0–4.25 mm. Lighter in color than typical *fumipennis*. Female bright green, tinted with fus-

cous, apexes of elytra hyaline. Male green, elytra brownish or fuscous. Darker specimens often have pronotum and scutellum clouded. Epimera unmarked in both sexes.

Occurring on honey locust, *Gleditsia triacanthos*, this variety ranges from Pennsylvania to Louisiana and Idaho.

Illinois Records.—CHAMPAIGN: June 5, 1889, Hart, 1♂. DONGOLA: on willow, May 13, 1916, 1♂. DUBOIS: May 23, 1917, 1♂; May 24, 1917, 2♂. MEREDOSIA: May 29, 1917, 3♂. URBANA: June 17, 1890, Marten, 1♂. WHITE HEATH: May 30, 1915, 1♂.

16. *Macropsis ferruginoides* (Van Duzee)

Pediopsis ferruginoides Van Duzee (1889b, p. 171).

Length of female 5.5–6.0 mm., male 5.0 mm. Marked with ferruginous above and yellow below. Pronotum darker on disc. Scutellum often with basal angles, apex, and two discal spots yellow. Elytra ferruginous, opaque; costa with a narrow yellow margin. A transverse hyaline band before apex across the crossveins of the anteapical cells. Epimera of both sexes with black spots. Face concave above as viewed from the side.

This species has been taken from a narrow-leaved willow. It is chiefly middle

western, but ranges as far west as Colorado and New Mexico.

Illinois Record.—WAUKEGAN: Aug. 24, 1917, 1♀.

17. *Macropsis nigricans* (Van Duzee)

Pediopsis trimaculata Van Duzee (1889b, p. 172). Preoccupied.

Pediopsis bifasciata Van Duzee in Osborn & Ball (1898, p. 118). Misidentification.

Macropsis nigricans Van Duzee (1916, p. 64). New name.

Length of female 5.5 mm., male 5.0 mm. Greenish brown, with black markings. Pronotum washed with fuscous, anterior impression usually brown or black. Scutellum greenish fulvous, with dark spots in basal angles. Each elytron hyaline, brown and black pigment on basal half variable, usually darker along costa and with spot at apex of clavus. Epimera with heavy black spots.

Known to occur on cottonwood, *Populus deltoides*, this species apparently is found only in the middle western region of the United States.

Illinois Records.—FREEPORT: July 2, 1917, 1♀. GRAFTON: June 26, 1934, DeLong & Ross, 3♀. GRAYS LAKE: June 10, 1936, Ross & Burks, 3♂, 4♀. KAMPSVILLE: June 27, 1934, DeLong & Ross, 1♀. PALOS PARK: June 19, 1933, Ross & Mohr, 1♀. PIKE: June 28, 1934, DeLong & Ross, 6♀.



Fig. 94.—*Macropsis trimaculata*.

18. *Macropsis insignis* (Van Duzee)

Pediopsis insignis Van Duzee (1889b, p. 171).

Length of female 5.0 mm., male 4.25 mm. Reddish brown, similar to and often confused with *trimaculata*. Pruinose when freshly collected. Pronotum ochraceous, disc dusky to the humeral angles. Scutellum ochraceous, a fuscous triangle within basal angles. Elytra paler on basal portions of costa, opaque except for the shiny veins and the apical margins of wings.

This is a widely distributed species from Pennsylvania to Colorado, and occurs on wild plum, *Prunus* spp.

Illinois Records.—DuBois: Aug. 9, 1917, 1 ♀. Eichhorn: June 13, 1934, DeLong & Ross, 1 ♂, 2 ♀.

19. *Macropsis trimaculata* (Fitch)

Pediopsis trimaculatus Fitch (1851, p. 60).

Length of female 5.0 mm., male 4.5 mm. Dark brown or black, with three light spots in a row on each elytron, fig. 94. Female dark brown; male almost black. Epimera in both sexes each with a black bar, this occasionally obscured in the male by heavy pigmentation. Female pronotum testaceous, a dusky spot on disc. Male pronotum fuscous. In both sexes scutellum cinereous with a dark triangular spot in each basal angle; elytron with a pellucid white spot near the branching of the first sector, another at the juncture of the anteapical and basal cells, and a third within the third and fourth apical cells.

Occurring principally on wild plum, *Prunus* spp., this species has rather recently come into economic prominence since it has been proved able to transmit the peach yellows virus and cause severe economic losses in peach orchards. It is recorded from the East and as far west as Colorado.

Illinois Records.—URBANA: Augerville, June 23, 1916, 1 ♂. NORTHERN ILLINOIS: 1 ♀.

3. *ONCOPSIS* Burmeister

Oncopsis Burmeister (1838, p. 27, pl. 10).

Fig. 92. Vertex short and broad, rounded produced, blunt. Face shorter and broader than in *Macropsis*. The striae of the pronotum are nearly transverse, not obliquely angled, and are usually not as coarse as in *Macropsis*.

The species of this genus are all shrub and tree inhabiting as far as known. Sixteen species have been recorded for North America, half of which occur in Illinois.

Due to color variations and a lack of structural characters, it is difficult at the present time to separate these species. The following key will serve to separate the female specimens fairly well, but a key to male structural characters has not been devised.

KEY TO SPECIES

1. Elytra each with five apical and three anteapical cells.....2
Elytra each with four apical and two anteapical cells.....8. **verticis**
2. Female seventh sternite truncate, rounded or angularly produced, notched at apex but without projecting teeth.....3
Female seventh sternite with small apical teeth each side of apical notch.....5
3. Female seventh sternite short, with a broad shallow notch; face usually dark brown or black.....1. **nigrinasi**
Female seventh sternite with a deeper notch; face usually pale.....4
4. Female seventh sternite long, rounded, with a deep U-shaped notch; female usually a shade of yellow marked with black or orange; male usually darker.....6. **variabilis**
Female seventh sternite long, triangularly produced, with a shallow emargination; color brown.....5. **sobrius**
5. Female seventh sternite with a broad shallow notch, teeth short, incurved; color gray; elytra subhyaline, spotted.....4. **cognatus**
Female seventh sternite triangular, with apical teeth more distinctly produced.....6
6. Elytra smoky to brown, with pale hyaline areas.....7
Elytra hyaline, nervures brown, each with a discal spot and the apex often dusky. Vertex dark brown to black, with a yellow band connecting the ocelli.....3. **pruni**
7. Gray to pale brown; female seventh sternite short, with small median teeth.....2. **minor**
Usually brownish to reddish brown; female seventh sternite longer, teeth larger, more conspicuous.....7. **fitchi**

1. *Oncopsis nigrinasi* (Fitch)

Athysanus nigrinasi Fitch (1851, p. 61).

Length 4 mm. Small, yellowish or often brownish, and with dark brown or black face. In the female, coloration is variable, but as a rule the front, inner margins of lorae, and apexes of femora are dark brown or black. In pale specimens the elytra are subhyaline and with two transverse brown-

ish bands. In dark specimens there are white spots on discal cells, on the anteapical cells, and at base and near apex of clavus. The male is usually uniform brownish, with a yellowish transverse band on vertex and on base of front. Genitalia: Female seventh sternite short and bilobate or sinuate on posterior margin; male with long narrow plates.

This eastern species is reported from hornbeam, viburnum, and hazel.

Illinois Records.—ELIZABETHTOWN: May 27–31, 1931, Dozier, 1 ♀. HARRISBURG: June 25, 1932, Ross, Dozier, & Park, 1 ♀. HEROD: June 8–11, 1935, DeLong & Ross, 4 ♀; June 24, 1936, DeLong & Ross, 2 ♀. KARNAK: June 14, 1934, DeLong & Ross, 1 ♀.

2. *Oncopsis minor* (Fitch)

Athysanus minor Fitch (1851, p. 60).

Length 4 mm. Small, resembling *fitchi*, with yellow to brownish color and hyaline elytra. Face coarsely punctured. Disc of pronotum, scutellum, and elytra usually dark in color. White spots on elytra next to scutellum, on discal cells, and on anteapicals. Genitalia: Female seventh sternite with posterior margin slightly produced medially and bearing a pair of short teeth separated by a shallow notch; male plates long and slender.

This species, found in the East, as well as Illinois, is reported as occurring on birch.

Illinois Record.—MEREDOSIA: May 29, 1917, 1 ♀.

3. *Oncopsis pruni* (Provancher)

Bythoscopus pruni Provancher (1890, p. 290).

Length 4.0–4.25 mm. Grayish, resembling *fitchi*, with hyaline elytra and brownish veins. Vertex coarsely punctured, black, with a broad yellow band connecting the ocelli; front coarsely punctured, yellow. Pronotum yellowish to gray, usually with two or three black points behind each eye. Scutellum pale, with dark basal angles. Elytral nervures brown, commissural nervure white, with brownish spots. Genitalia: Female seventh sternite triangularly produced, with a pair of median acute teeth.

This is a northern transcontinental species known to occur on wild *Prunus*. In recent years transmission of peach yellows has been attributed to it.

Illinois Record.—DUBOIS: May 24, 1917, 1 ♂.

4. *Oncopsis cognatus* (Van Duzee)

Bythoscopus cognatus Van Duzee (1890d, p. 225).

Length 5 mm. In size and general form resembling *fitchi* but gray in color instead of brownish, and female seventh sternite has a broad shallow depression and minute teeth at middle. In *fitchi*, seventh sternite is triangularly produced. Vertex dull yellow to gray, front brownish to black, pronotum paler on anterior margin. Vertex and pronotum coarsely punctate. Elytra gray, each with a brownish area from tip of clavus to base of anteapical cells. Genitalia: Female seventh sternite longer than in *pruni*, apical margin slightly concave, teeth minute, depressed; male plates long and slender.

This species has been collected from hazelnut, *Corylus americana*, in the northeastern United States.

Illinois Records.—ALGONQUIN: July 8, 1897, 1 ♀. HEROD: May 29, 1935, Ross & Mohr, 1 ♂.

5. *Oncopsis sobrius* (Walker)

Bythoscopus sobrius Walker (1851a, p. 874).

Length 5 mm. Yellowish, with brown elytra. Vertex, pronotum, and scutellum yellow, elytra darker, tawny to brown. Elytra with commissural line alternately marked with paler spots. Genitalia: Female seventh sternite similar to that of *variabilis*, with a small, median, rounded notch.

This species has been collected from birch, *Betula* sp., and associated plants in New England and Canada.

Illinois Record.—SAVANNA: June 13, 1917, 1 ♀.

6. *Oncopsis variabilis* (Fitch)

Athysanus variabilis Fitch (1851, p. 60).

Length 5 mm. Color and color pattern extremely variable. Of the more common color forms, some are bright yellow, with a black line or band along claval suture, and some are reddish brown, with yellow clavus. Others are yellow throughout, or almost entirely black, especially in the males. Genitalia: Female seventh sternite pro-

duced, and with a median conspicuous U-shaped notch.

Northern transcontinental in distribution, this species has been taken from birch, *Betula* sp., and specimens that are apparently of this species have been collected from hazelnut, *Corylus americana*, and alder, *Alnus* sp.

Illinois Record.—HARRISBURG: June 25, 1932, Ross, Dozier, & Park, 1 ♀.

7. *Oncopsis fitchi* Van Duzee

Athyas fenestratus Fitch (1851, p. 60).
Name preoccupied.

Oncopsis fitchi Van Duzee (1916, p. 65).
New name.

Length 4.5 mm. Brownish to reddish brown; elytra usually with pale hyaline spots, which are often absent in the males. Face and vertex dusky to brown, with a yellowish transverse band between ocelli. Face sometimes piceous. Basal angles of scutellum usually darker than pronotum. Margin of each clavus along scutellum hyaline, a hyaline spot near apex, and another on disc; also a hyaline spot on anteapical cells. Genitalia: Female seventh sternite triangularly produced, with two small median teeth; male plates long and narrow.

This species occurs on birch, *Betula* sp. It is distributed through the northern United States from Maine to Colorado.

Illinois Record.—HARDIN: June 5–9, 1932, Dozier, 1 ♀.

8. *Oncopsis verticis* (Say)

Jassus verticis Say (1831, p. 308).

Oncopsis distinctus Van Duzee (1890d, p. 225).

Length 3.5–4.5 mm. Readily distinguishable from other species of the genus by the four apical cells and two anteapical cells.

Color variable in both sexes, but male usually darker than female. Female usually yellowish to pale brownish. Male usually brown, with commissural line and large costal spot on apical portion of each elytron pale. Vertex, pronotum, and scutellum punctured with fuscous. Scutellum with a dark triangular spot in each basal angle. Elytra brown, each darker on clavus, with a white spot before apex. Venter yellow. Genitalia: Female seventh sternite long, with a distinct U-shaped median notch, apex rounded; male plates long and narrow.

The species has been taken commonly from black walnut, *Juglans nigra*. Its range is from Maine to Colorado and south to Tennessee; it is rather abundant in different areas of Illinois.

Illinois Records.—Many males and females, taken May 25 to October 12, are from Albion, Algonquin, Alton, Castle Rock, Cedar Lake, Danville, Dixon Springs, Freeport, Galena, Grafton, Grand Detour, Hardin, Havana, Herod, Kankakee, Keithsburg, Lacon, Makanda, Marshall, Monticello, Muncie, Normal, Oquawka, Pike, Pinkstaff, Pulaski, Quincy, Urbana, Vienna, Weldon Springs, and White Heath.

Subfamily NIONINAE

A single genus of this subfamily occurs in the United States.

4. *NIONIA* Ball

Nionia Ball (1915, p. 165).

This genus, which includes but a single species, distributed from the southeastern states to Illinois, was formerly placed in the subfamily with *Macropsis* and *Oncopsis*.



Fig. 95.—*Nionia palmeri*: a, adult; b, male genitalia; c, nymph. (From Osborn.)

Nionia palmeri (Van Duzee)

Goniagnathus palmeri Van Duzee (1891, p. 171).

Figs. 16, 95. Length 4–5 mm. Short, robust, head conically pointed, vertex almost parallel margined and so strongly arched that the anterior portion of the pronotum is produced decidedly anterior to the anterior margins of the eyes. Shiny black, resembling a *Macropsis* in general appearance. Apical nervures of elytra, ventral margins of eyes, and antennae reddish. Pronotum strongly punctured; distinct lines of punctures bordering veins of elytra. Female seventh sternite slightly produced at middle, pygofers short and broad, obtusely triangular; male valve concealed, plates triangular, acutely angled at apexes.

This is a grass-feeding species in moist woodland areas, and is common throughout central and southern Illinois.

Illinois Records.—Males and females, taken May 7 to August 17, are from Alton, Alto Pass, Danville, Dixon Springs, Elizabethtown, Fern Cliff, Grafton, Herod, Oakwood, Odin, and Vienna.

Subfamily AGALLIINAE

The vertex is short and broad, the ocelli are on the face, and each hind wing has four apical cells.

Three of the five Nearctic genera listed by DeLong & Knull (1945) as belonging to this subfamily occur in Illinois. The subfamily was treated for North America by Oman (1933), who records about 80 species for the United States. The majority of these species are recorded from only western and southwestern states, but several are widely distributed.

KEY TO GENERA

1. Vertex distinctly longer at middle than next to eyes, fig. 99; pronotum in large part transversely rugulose.....7. *Aceratagallia*
Vertex usually shorter at middle than next to eyes, fig. 96; pronotum finely punctured and granulate.....2
2. Vertex distinctly shorter at middle than next to eyes; posterior margin of head sinuate behind eyes, figs. 96, 97.....5. *Agalliopsis*
Vertex of nearly uniform length throughout its width; margin of head straight behind eyes, fig. 102.....6. *Agallia*

5. *AGALLIOPSIS* Kirkaldy

Agalliopsis Kirkaldy (1907, p. 30).

Fig. 114. Median portion of vertex very short, usually longer next to eyes; posterior margin sinuately curved laterally and extending some distance behind the eyes. Lateral margins of pronotum obsolete. Elytra long and narrow. Male styles forked.

Two species generally distributed over the eastern states have been collected in Illinois.

KEY TO SPECIES

- Female seventh sternite, fig. 97C, truncate or slightly produced; male plates, fig. 97B, elongate narrow, surpassing pygofers in length, concavely constricted at middle. Pronotum, fig. 97A, unmarked, or with a median fuscous line and a spot on each side.....1. *peneoculata*
Female seventh sternite, fig. 96C, broadly and deeply concave; male plates, fig. 96B, short, triangular, gradually tapered from bases to blunt apexes, distinctly shorter than pygofers. Pronotum, fig. 96A, with at least two spots on each side of middle; elytra pale, each with a transverse fuscous band across the middle of clavus....2. *novella*

1. *Agalliopsis peneoculata* Oman

Agalliopsis peneoculata Oman (1933, p. 17).

Fig. 97A. Length 4.0–4.5 mm. Resembling *oculata* in size and form but with the elytra concolorous except for an indistinct transverse smoky bar just posterior to the forking of the first sector. Vertex shorter at middle than next to eyes. Pronotum with posterior margin nearly straight. Elytra long and tapering. Genitalia: Female seventh sternite, fig. 97C, with posterior margin broad and convex. Male plates, fig. 97B, long, lateral margins concave on basal two-thirds, tips bluntly rounded; aedeagus, fig. 106, long and slender, the tip in dorsal view appearing very broad and somewhat bilobed.

This species was previously recorded from New York, Connecticut, and Michigan.

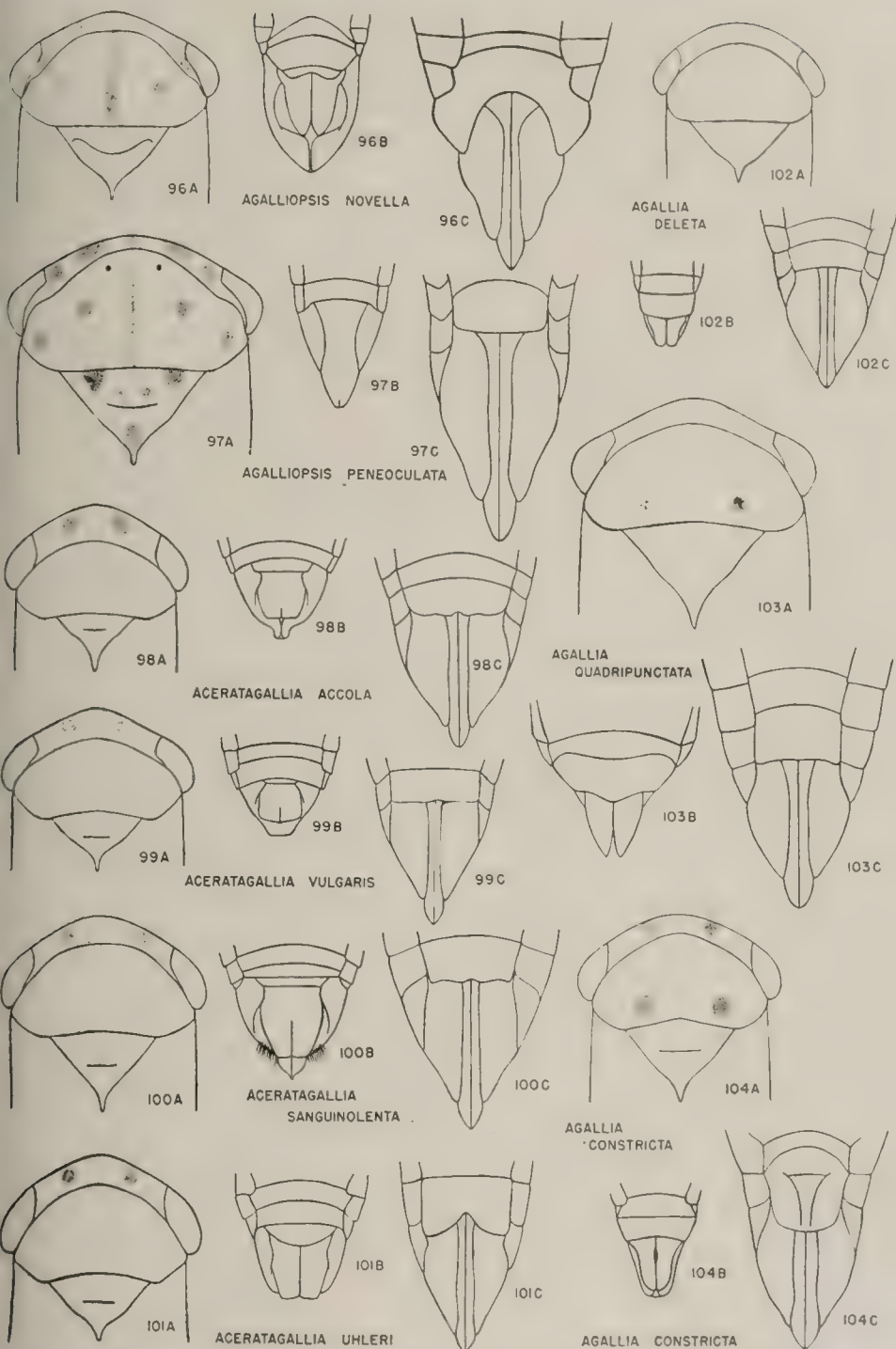
Illinois Record.—KARNAK: June 14, 1934, DeLong & Ross, 1 ♂, 10 ♀.

2. *Agalliopsis novella* (Say)

Jassus novellus Say (1831, p. 309).

Macropsis nobilis Forbes (1885, p. 22).

Fig. 96A. Length 3.5–4.0 mm. Color usually light testaceous, sometimes darker;

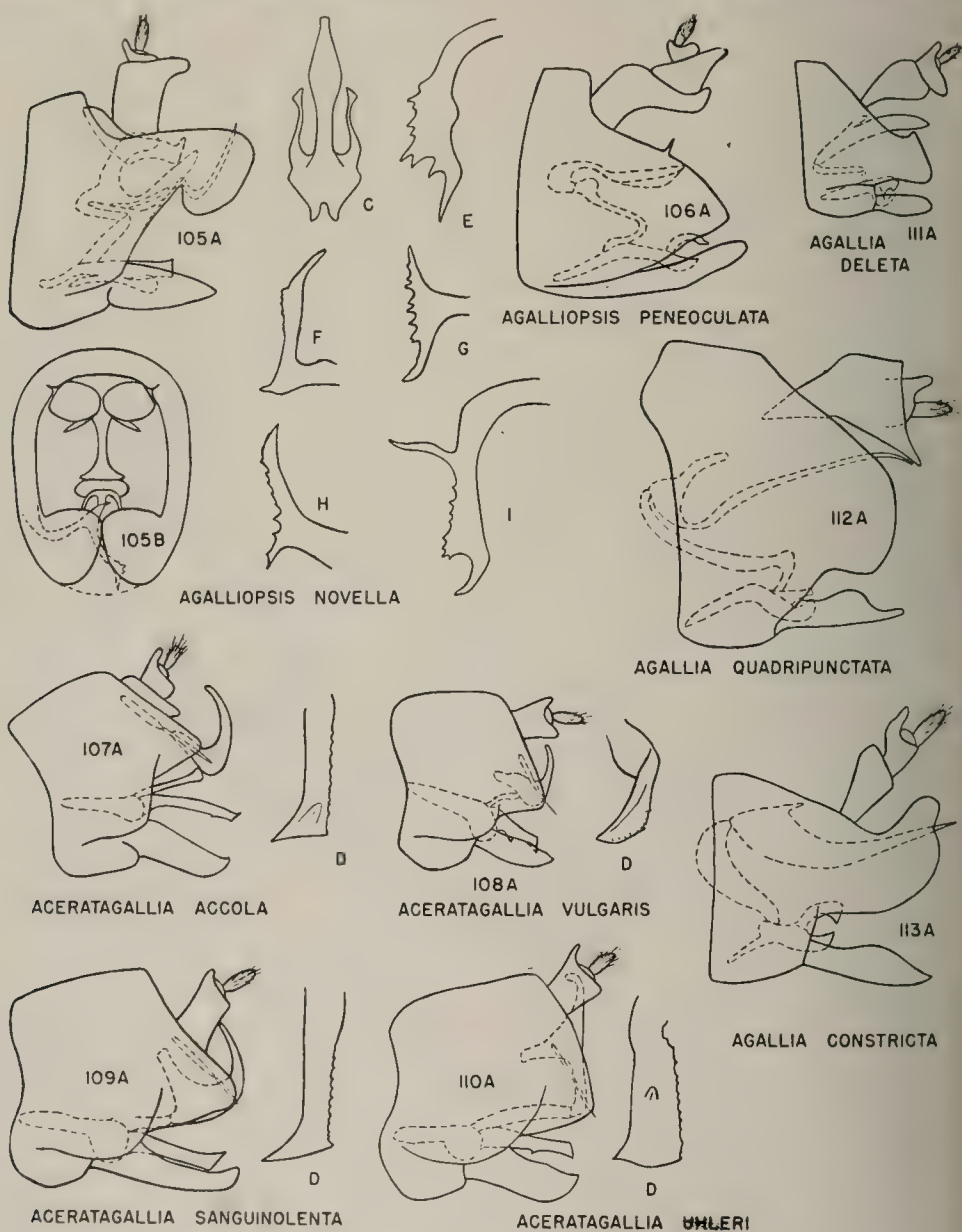


Figs. 96-104.—Agallinae. A, head and pronotum; B, male external genitalia; C, female genitalia. (From Oman.)

margins of ocelli, a round spot behind each ocellus on vertex, and an elongate spot next to each eye black. Pronotum with a median stripe and a spot on either side brown. All of these markings may vary in intensity. Elytra brown to black, veins pale. Genitalia: Female seventh sternite, fig. 96C, with posterior margin broadly and roundedly

excavated at middle, lateral lobes rounded or somewhat pointed. Male valve, fig. 96B, short, emarginate posteriorly; plates semi-tubular, bluntly rounded at apexes, and scarcely covering the opening of the large genital chamber. The internal male genital structures are variable in form, fig. 105.

This is a common species on herbaceous



Figs. 105-113.—Agalliinae, male genitalia. A, lateral view; B, caudal view; C, aedeagus; D, style; E-I, pygofer hook showing variation. (From Oman.)



Fig. 114.—*Agalliopsis novella*: a, adult; b, c, nymph; d, face; e, elytron; f, female genitalia; g, h, male genitalia. (From Osborn.)

vegetation, and occurs throughout the eastern United States.

Illinois Records.—Many males and females, taken March 20 to October 2, are from Aldridge, Algonquin, Alton, Alto Pass, Anna, Apple River Canyon State Park, Augerville, Carbondale, Cave in Rock, Champaign, Chester, Danville, Dixon Springs, Dolson, Dongola, East Cape Girardeau, Eichorn, Elizabethtown, Fern Cliff, Fountain Bluff, Freeport, Golconda, Grand Detour, Hardin, Havana, Herod, Homer, Jonesboro, Kankakee, Karnak, Mahomet, Makanda, Monmouth, Monticello, Muncie, Normal, Oakwood, Olive Branch, Oregon, Port Byron, Quincy, Rock Island, Savanna, Shawneetown, Sparta, Topeka, Urbana, Ursa, Vienna, Volo, Weldon Springs, White Heath, White Pines Forest State Park, Wolf Lake, and Zion.

6. *AGALLIA* Curtis

Agallia Curtis (1833, p. 192).

Vertex short, usually about uniform in length over its entire width; posterior margin evenly curved, not extending behind the eyes laterally. Pronotum short, lateral margins almost obsolete. Elytra usually short.

This genus contains two of the most common species of leafhoppers in Illinois. One of them, *constricta*, is often found in large numbers on economic crops.

KEY TO SPECIES

1. Pale brown, without dark spots on vertex and pronotum, fig. 102*A* 3. *deleta*
- Pale to dark brown, with four distinct black spots on vertex and pronotum, figs. 103*A*, 104*A* 2

2. Robust; female seventh sternite, fig. 103*C*, truncate or slightly concave; male plates, fig. 103*B*, narrowed and pointed, tips diverging 1. *quadripunctata*
- More slender, wedge shaped; female seventh sternite, fig. 104*C*, roundedly and convexly produced; male plates, fig. 104*B*, narrowed near base and then produced, convexly rounded to blunt, and with appressed apexes 2. *constricta*

1. *Agallia quadripunctata* (Provancher)

Bythoscopus quadripunctatus Provancher (1872, p. 376).

Ulopa canadensis Van Duzee (1892*c*, p. 301). (Immature specimens).

Fig. 103*A*. Length 4 mm. Robust, varying in color from pale brown to fuscous. Two obliquely converging black spots on front margin of vertex and a pair of black spots on pronotum near posterior margin. Elytra light brown, veins pale. Female seventh sternite, fig. 103*C*, with posterior margin truncate. Male plates, fig. 103*B*, small, acutely angled, their lateral margins convex, the plates as long as the pygofers. Male internal genitalia as in fig. 112.

Experimental work reported by Black & Oman (1947) indicates that in the eastern United States the species normally reproduces parthenogenetically. Their cultures of the species were maintained on crimson clover, *Trifolium incarnatum*.

A common species in the northeastern United States, *quadripunctata* occurs abundantly in moist open woodland areas.

Illinois Records.—Many males and females, taken March 4 to January 16, are from Algonquin, Alto Pass, Antioch, Beach, Bloomington, Carbondale, Champaign,

Chester, Chicago, Cypress, Danville, Dixon Springs, Dolson, Dongola, Eichorn, Elizabethtown, Fountain Bluff, Fox Lake, Geff, Golconda, Grafton, Herod, Homer, McHenry, Mahomet, Monticello, Muncie, Normal, Oakwood, Olive Branch, Pulaski, Quincy, Rago, Rock Island, Springfield, Thebes, Urbana, Vienna, White Heath, Wilmington, and Zion.

2. *Agallia constricta* Van Duzee

Agallia constricta Van Duzee (1894a, p. 90).

Fig. 104A. Length 3.25–3.75 mm. Light brown in color, a pair of black spots on the anterior margin of the vertex behind ocelli, and another pair behind these on the posterior margin of the pronotum. Elytra brown, veins paler. Female seventh sternite, fig. 104C, twice as long as preceding, keeled medially; lateral angles produced and rounded, central portion of posterior margin shallowly notched on median line. Male plates, fig. 104B, broad at bases, narrowed to median constriction and then slightly widened caudally, plates together rounded at apex; pygofers slightly longer and broader than plates. Male internal genitalia as in fig. 113.

This is probably the most common species of *Agallia* in the eastern United States.

Illinois Records.—Many males and females, taken April 18 to September 24, are from Albion, Alton, Alto Pass, Anna, Cache, Cairo, Carbondale, Carman, Cave in Rock, Cobden, Dixon, Dolson, Dongola, Dubois, East Cape Girardeau, Eichorn, Elizabethtown, Fountain Bluff, Fulton, Golconda, Grand Tower, Harrisburg, Havana, Herod, Homer, Kampsville, Karnak, Kirkwood, La Rue, Luna, Macomb, Meredosia, Metropolis, Monmouth, Mount Carmel, Mount Sterling, Muncie, Murphysboro, Niota, Oakwood, Oquawka, Parker, Pike, Pulaski, Putnam, Quincy, Rosiclare, Saratoga, Seymour, Shawneetown, Sparta, Sumner, Texas City, Thebes, Unity, Urbana, Ursa, Vandalia, Vienna, and Wolf Lake.

3. *Agallia deleta* Van Duzee

Agallia deleta Van Duzee (1909a, p. 210).

Agallia immaculata Lathrop (1917, p. 120).

Fig. 102A. Length 2.5–3.0 mm. Robust, vertex uniform in length and evenly rounded. Color usually pale brown, without definite markings. Elytra subhyaline, appear-

ing dark. Males frequently darker than females. Female seventh sternite, fig. 102C, short, posterior margin truncate but often appearing concave. Male plates, fig. 102B, small, broad at base, abruptly narrowed to blunt apices; aedeagus in lateral view appearing broad and almost straight, in dorsal view appearing laterally compressed and with apex divided for a short distance; the flaplike projections of the posterior margins of pygofers are turned slightly inward; internal genitalia as in fig. 111.

This is a common grass species in the southern states and along the Atlantic sea coast. It possibly occurs in Illinois.

7. *ACERATAGALLIA* Kirkaldy

Aceratagallia Kirkaldy (1907, p. 30).

Vertex short, usually distinctly longer at middle than next to eyes; posterior margin broadly rounded, not produced behind the eyes. Lateral margins of pronotum very short. Elytra about as long as abdomen. Male styles not forked.

This genus contains some of the smallest individuals of the subfamily; a few species are extremely abundant and important economic pests. Within the genus the species are almost identical on the basis of external characters. The males, however, are readily identified by characters of the internal genitalia. The females are difficult to identify on any basis, but the few characters that will aid in their identification have been offered in the following key.

KEY TO SPECIES

1. Females.....5
Males.....2
2. Each style, fig. 108D, strongly curved laterally, twisted and somewhat keeled.....**1. vulgaris**
Each style not strongly curved or twisted, but straight and boat shaped.....3
3. Each style, fig. 110D, broad, outer point slightly produced; aedeagus shaft, fig. 110A, straight, hooked at apex.....**4. uhleri**
Each style narrowed, foot shaped, outer point sharp, conspicuous; aedeagus shaft strongly curved dorsally.....4
4. Each style, fig. 107D, with ventral tooth. Size 2.5–2.75 mm., dark in color. Male plates, fig. 98B, shorter than pygofers.....**2. accola**
Each style, fig. 109D, without ventral tooth. Size 2.75–3.0 mm., brown to gray in color. Male plates, fig. 100B, reaching apex of pygofers.....**3. sanguinolenta**

5. Female seventh sternite, fig. 101C, broadly, rather shallowly, and angularly excavated.....4. **uhleri**
 Female seventh sternite truncate or sinuate, not excavated, as in figs. 98C-100C.....
 n. Length 3.0-3.25 mm.....
 Smaller in size, 2.75-3.0 mm.....
1. **vulgaris**, 2. **accola**

1. *Aceratagallia vulgaris* Oman

Aceratagallia vulgaris Oman (1933, p. 60).

Fig. 99A. Length 2.5-3.0 mm. Similar to *sanguinolenta* but usually paler in color. Yellowish brown to darker brown, vertex with a black spot above each ocellus; often a dark median line on vertex and pronotum. Elytra subhyaline, veins brown. Female seventh sternite, fig. 99C, with posterior margin almost truncate, faintly notched at middle. Male valve, fig. 99B, very short, often concealed by eighth sternite; plates short and broad, wider at apex than at base, apexes almost truncate. Male internal genitalia as in fig. 108.

This is a common form in the Mississippi River valley. It occurs abundantly upon the Illinois prairies. It can be distinguished from all the other eastern species by the twisted styles. For many years it was named *cinerea* (Osborn & Ball) and is commonly found in eastern and midwestern collections under that label. The true *cinerea* is a western species.

Illinois Records.—Many males and females, collected June 12 to October 2, are from Albion, Alto Pass, Alton, Ashley, Barry, Carbondale, Cave in Rock, Dongola, Dubois, Fairfield, Fountain Bluff, Galena, Geff, Gibsonia, Murphysboro, Oak Lawn, St. Anne, St. Joseph, Shawneetown, Vienna, and White Pines Forest State Park.

2. *Aceratagallia accola* Oman

Aceratagallia accola Oman (1933, p. 57).

Fig. 98A. Length 2.5-3.0 mm. Dark brown, with a brown spot above each ocellus and a brown area next to each eye. Resembling *sanguinolenta* but smaller, more robust, and darker in color. Female seventh sternite, fig. 98C, slightly produced at middle, posterior margin shallowly and roundly notched at middle, slightly sinuate on either side of notch. Male valve, fig. 98B, short, truncate, appearing transverse; plates

short, slightly narrowed to truncate apexes. Male internal genitalia as in fig. 107.

This eastern species cannot be distinguished easily from *sanguinolenta*, but the smaller size and darker color will usually assist in its identity. An examination of the male internal genitalia will easily verify or disprove the identification from external characters.

Illinois Records.—DUBOIS: sweeping from grass, July 2, 1909, 1♂, 1♀. FOREST CITY: sand, June 6, 1905, Hart, 1♂.

3. *Aceratagallia sanguinolenta* (Provancher)

Bythoscopus sanguinolenta Provancher (1872, p. 376).

Bythoscopus siccifolius Uhler (1877, p. 359).

Fig. 100A. Length 2.75-3.25 mm. Robust, light brown with fuscous markings. A black or dark brown spot above each ocellus, a light brown patch next to each eye, and a longitudinal light brown stripe each side of pale median line. Pronotum irregularly marked with fuscous on anterior margin and with indistinct longitudinal stripes. Elytra pale brown, veins brown, marked with white on clavus. Female seventh sternite, fig. 100C, as in *accola*, but with lateral angles more distinct, posterior margin shallowly and medially notched.

Male valve, fig. 100B, short, truncate, transverse; plates rather broad, lateral margins convexly and roundly narrowed to truncate apexes. Male internal genitalia as in fig. 109.

This is the most widespread and abundant species of the genus. It occurs throughout the eastern states and Canada and has been recorded as far west as Utah and Arizona. It occurs abundantly upon many economic crops and causes heavy feeding injury. Commonly known as the clover leafhopper, it is probably most abundant upon legume hosts.

Illinois Records.—Many males and females, collected June 13 to October 3, are from Albion, Alton, Amboy, Antioch, Anvil Rock, Apple River Canyon State Park, Barry, Beach, Cave in Rock, Decatur, Des Plaines, Dixon, Dixon Springs, Eichorn, Evergreen Park, Fulton, Galena, Gibsonia, Grafton, Grand Tower, Hanover, Havana, Herod, Kampsville, Kimmunity, Marshall, Norris City, Oak Lawn, Oakwood, Ogden, Pike, Port Byron, St. Anne, St. Joseph, Savanna, Sheffield, Springfield, Starved

Rock State Park, Summit, Thomson, Vienna, Volo, Watson, White Pines Forest State Park, and Zion.

4. *Aceratagallia uhleri* (Van Duzee)

Agallia uhleri Van Duzee (1894a, p. 91).

Fig. 101A. Length 3.25–3.75 mm. Resembling *sanguinolenta* but more slender and with the female seventh sternite deeply notched posteriorly. Vertex slightly swollen between ocelli, longer at middle than next to eyes, posterior margin broadly and evenly rounded. Elytra each with three anteapical cells. Color brownish cinereous. Face pale yellowish. Spots on vertex above ocelli round and black. Scutellum with triangular basal spots black and with a dark transverse suture. Elytra subhyaline, sometimes fuscous along commissural line, veins dark, occasionally with white spots. Genitalia: Female seventh sternite, fig. 101C, with posterior margins angularly excavated nearly half way to the base. Male plates, fig. 101B, heavy, lateral margins straight, slightly converging, tips truncate, about equaling pygofer in length; styles, fig. 110D, each broad on posterior portion, tip truncate, outer point slightly produced, inner margin serrate; ventral tooth of style sharp and slightly hooked; tip of aedeagus, fig. 110A, as seen in lateral view, bent sharply upward.

This species is common in the plains region west of the Mississippi River.

Illinois Records.—ALTON: June 26, 1934, DeLong & Ross, 3 ♀. APPLE RIVER CANYON STATE PARK: July 11, 1934, Frison & DeLong, 1 ♀. PIKE: Mississippi floodplain, June 28, 1934, 1 ♀.

Subfamily BYTHOSCOPINAE

This subfamily is characterized by a short vertex and by forewings that are set with short conspicuous setae.

Only one genus, *Stragania*, is known to occur in the United States.

8. *STRAGANIA* Stål

Stragania Stål (1859, p. 49).

Pachyopsis Uhler (1877, p. 466).

Gargaropsis Fowler (1896, p. 167).

Figs. 17, 29. Head, including eyes, narrower than pronotum, very short, parallel margined, slightly but broadly rounded, almost truncate. Pronotum large, finely and

transversely striate. Elytra short and broad, deeply punctured, covered with hairs.

Twenty species are known to occur in North America. Of this number only three are found in the eastern United States and one of these occurs only in that portion along the coast of the Gulf of Mexico.

1. *Stragania apicalis* (Osborn & Ball)

Macropsis apicalis Osborn & Ball (1898, p. 64).

Macropsis alabamensis Baker (1900a, p. 58).

Fig. 115. Length 4.5–5.0 mm. Broad and robust, green, with anterior half of pronotum washed with yellow. Elytra green, covered with greenish hairs. A faint line along claval suture, apex of clavus, and apical margin of each elytron brown to black. Venter and legs deep green, tips of tarsi black. Each elytron exceeding abdomen in length and with a broad appendix, the whole surface except appendix covered with short hair. Female seventh sternite with posterior margin broadly rounded and with slight notch at center. Male valve long, truncate, plates rather short, triangular, apices angled.

This is a common species throughout the state on honey locust.

Illinois Records.—Many males and females, taken May 27 to September 22, are from Alton, Barry, Byron, Danville, Dar-

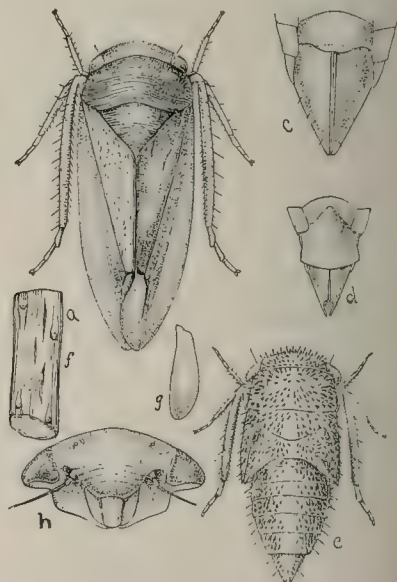


Fig. 115.—*Stragania apicalis*. (From Osborn.)

win, Dongola, Dubois, Du Quoin, Eichorn, Elizabethtown, Fairfield, Grand Tower, Hanover, Ludlow, Makanda, Meredosia, Monticello, Paxton, Shawneetown, Urbana, and Vienna.

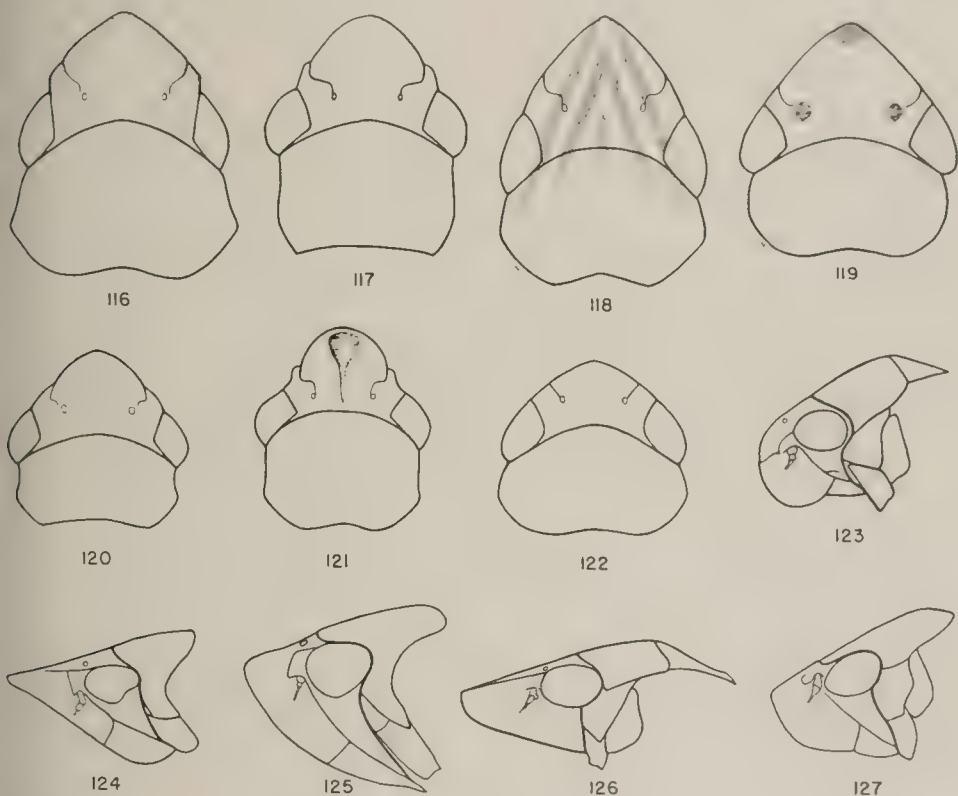
Subfamily TETTIGONIELLINAE

The cylindrical-shaped body with ocelli on the disc of vertex; and the three apical cells in the hind wing will usually distinguish this group. The frontal sutures extend over the anterior margin of vertex nearly to the ocelli.

Representatives of 11 of the 15 Nearctic genera in this group occur in Illinois. More species of the subfamily occur in the West than in the East.

KEY TO GENERA

1. Posterior corner of pronotum nearly right angled, fig. 117; two claval veins nearly always joined, as in figs. 128, 129. 2
- Posterior corner of pronotum obtuse or rounded; claval veins, if present, never touching. 3
2. Face bulbously inflated, fig. 123; claval veins at most slightly coalesced or connected by a short veinlet, fig. 129. 11. *Oncometopia*
- Face convexly sloping, fig. 126; claval veins broadly coalesced and sometimes with secondary branches, fig. 128. 12. *Homalodisca*
3. Margin of vertex with a distinct angulate swelling above each antenna, fig. 127; vertex with a deep longitudinal furrow from near base almost to apex, fig. 121. 9. *Aulacizes*
- Margin of vertex without an angulate swelling above antenna; vertex at most



Tettigoniellinae, heads and thoraxes

- Fig. 116.—*Graphocephala coccinea*.
 Fig. 117.—*Oncometopia undata*.
 Fig. 118.—*Sibovia occatoria*.
 Fig. 119.—*Plesiommatia tripunctata*.
 Fig. 120.—*Cuerna lateralis*.
 Fig. 121.—*Aulacizes irrorata*.

- Fig. 122.—*Kolla bifida*.
 Fig. 123.—*Oncometopia undata*.
 Fig. 124.—*Draculacephala producta*.
 Fig. 125.—*Carnocephala flaviceps*.
 Fig. 126.—*Homalodisca triquetra*.
 Fig. 127.—*Aulacizes irrorata*.

- depressed toward middle of anterior margin.....4
4. Posterior margin of pronotum broadly and evenly emarginate and almost parallel with anterior margin, fig. 120.....10. **Cuerna**
- Posterior margin of pronotum very shallowly emarginate to subtruncate, and not parallel with anterior margin.....5
5. Elytra with apical part reticulate veined, fig. 130.....6
- Elytra not reticulate veined, as in fig. 129.....7

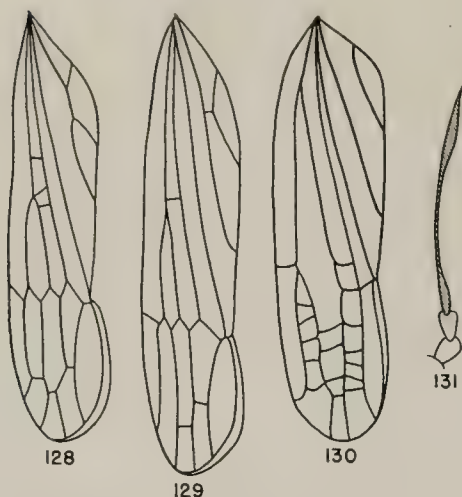


Fig. 128.—*Homalodisca triquetra*, elytron.

Fig. 129.—*Oncometopia undata*, elytron.

Fig. 130.—*Draculacephala* sp., elytron.

Fig. 131.—*Helochara communis*, ♂ antenna.

6. Front appearing nearly straight in profile, fig. 124; vertex flattened, depressed behind apex and anterior to ocelli, fig. 134.....19. **Draculacephala**
- Front appearing convex in profile, fig. 125; vertex slightly convex and without depressions.....16. **Carneocephala**
7. Entire upper surface closely punctured, uniform green and rather dull in luster; antenna of male enlarged or flattened at apex, fig. 131.....15. **Helochara**
- Upper surface nearly always smooth, at least elytra unpunctured; antenna of male slender.....8
8. Vertex pointedly produced, with margins nearly straight from eye to apex, fig. 119; clavus with one vein; elytra white, with longitudinal veins broadly striped with brown.....18. **Plesiommata**
- Vertex more bluntly produced, with margins more convex from eye to apex, as in fig. 118; clavus usually with two distinct veins, but sometimes veins absent.....9
9. Antennae at least half as long as body; head and pronotum with a median and two pairs of narrow diagonal dark stripes, fig. 118.....21. **Sibovia**

- Antennae not longer than width of head; head and pronotum without diagonal stripes.....10
10. Head wider than pronotum, fig. 31; anterior margin of vertex with a median dark spot usually not joined by any other markings.....20. **Neokolla**
- Head usually distinctly narrower than pronotum; dark spot at anterior margin of vertex, if present, joined by other markings.....11
11. Vertex less than one and one-half times as wide as long; face usually very pale yellowish; anterior margin of vertex with a narrow dark band from eye to eye, fig. 116.....17. **Graphocephala**
- Vertex at least one and two-thirds times as wide as long; face usually dark; anterior margin of vertex without a distinct narrow band, as in fig. 122.....12
12. Brown to shiny black, without black bands.....13. **Ciminus**
- Green, with black transverse bands on vertex and pronotum, fig. 133.....14. **Kolla**

9. *AULACIZES* Amyot & Serville

Aulacizes Amyot & Serville (1843, p. 571).

Figs. 121, 127. Posterior corner of pronotum obtusely rounded to the slightly emarginate posterior margin; pronotum narrower than head. Lateral margin of vertex with an angulate swelling above antennal base; anterior margin evenly rounded; disc of vertex with a deep longitudinal furrow, which is broadened anteriorly behind apex. Front appearing very convex in profile and distinctly angled with vertex. Claval veins not joined.

Two species are recorded in this genus for the United States. One is known only from Florida, and the other is widely distributed throughout the eastern United States.

1. *Aulacizes irrorata* (Fabricius)

Cicada irrorata Fabricius (1794, p. 33).

Cicada nigripennis Fabricius (1794, p. 32).

Aulacizes rufiventris Walker (1851a, p. 796).

Length 12.5 mm. Reddish brown, irrorate with yellow. Head triangular, apex rounded, fig. 121. Vertex a little shorter than basal width, surface irregular and with median furrow and carinate margin. Pronotum hexagonal, coarsely pitted. Color varying from light to dark reddish brown, with black blotches on vertex and scutellum. Spots on costal margin of each elytron and many irrorations yellow. Female seventh sternite with posterior margin broadly

rounded, shallowly notched at middle. Male plates together concavely triangular.

Frequently taken from rank herbaceous growths of vegetation and occurring many times in the shrubby habitats, this species occurs throughout the eastern United States and as far west as Texas.

Illinois Records.—Many males and females, taken April 17 to October 5, are from Aldridge, Ashley, Brownfield, Cave in Rock, Central City, Centralia, Charleston, Danville, Dixon Springs, Dolson, Dongola, Dubois, East St. Louis, Elizabethtown, Fern Cliff, Fountain Bluff, Golconda, Grafton, Grand Tower, Hardin, Havana, Herod, Homer, Jacksonville, Jonesboro, Makanda, Manchester, Marshall, Metropolis, Muncie, Oakwood, Parker, Pine Hills, Pounds, Quincy, St. Joseph, Starved Rock State Park, Stonefort, Urbana, Vienna, West Union, White Heath, and Wolf Lake.

10. *CUERNA* Melichar

Cuerna Melichar (1924, p. 199).

Fig. 120. Posterior corner of pronotum obtuse, posterior margin broadly and evenly emarginate, almost parallel with anterior margin; pronotum narrower than head. Lateral margin of vertex slightly rounded above antennal base; anterior margin a little angulate at apex. Disc of vertex a little depressed. Claval veins not joined.

Fourteen species are recorded in the genus by DeLong & Knull (1945). Two species have been taken in Illinois; the others are western and southwestern (Oman & Beamer 1944).

KEY TO SPECIES

Elytra reddish, wing veins dark; surface of elytra finely rugose between veins

..... **1. *lateralis***
Elytra black; surface of elytra, especially in basal region, with distinct punctures

..... **2. *limbata***

1. *Cuerna lateralis* (Fabricius)

Cercopis lateral Fabricius (1798, p. 524).

Cercopis marginella Fabricius (1803, p. 96).
New name.

Cercopis costalis Fabricius (1803, errata). New name.

Tettigonia striata Walker (1851a, p. 775).

Tettigonia lugens Walker (1851a, p. 775).

Tettigonia pyrrhotelus Walker (1851a, p. 775).

Length 7-8 mm. Elytra red, marked with black nervures. Vertex and pronotum black,

irrorate with yellow, reflexed portions margined with yellow. Scutellum black, median line and other markings yellow. Face black, with very small yellow spots; margin of body with a yellow stripe extending from apex of vertex to each eye, and on each side of thorax and abdomen to pygofer. Female seventh sternite truncate posteriorly. Male plates triangular, a little longer than basal width.

Abundant in pastures and in herbaceous growth in cut-over areas, this species is distributed throughout the eastern United States and occurs as far west as California.

Illinois Records.—ALTON: June 26-27, 1934, DeLong & Ross, 2♂, 3♀. CAVE IN ROCK: Oct. 2, 1934, Ross & Frison, 2♂, 2♀. GRAFTON: June 26, 1934, DeLong & Ross, 2♂; Oct. 5, 1939, Ross & Burks, 1♀.

2. *Cuerna limbata* (Say)

Tettigonia limbata Say (1825, p. 340).

Length 8 mm. Similar in size and shape to *lateralis*, but black, with a few very small yellowish spots on vertex, pronotum, and scutellum. Face black, with small yellow spots. Surface of elytra, especially in basal region, distinctly punctured. Female seventh sternite similar to that of *lateralis*.

This species has been recorded from the middle western states and as far west as California and Colorado.

Illinois Record.—OAKWOOD: Middle Fork, April 26, 1911, 2♀.

11. *ONCOMETOPIA* Stål

Oncometopia Stål (1869, pp. 60, 62).

Figs. 117, 123. Head broader than pronotum, vertex rounded, obtuse, disc convex, rounding to front, eyes prominent, front gibbous; a distinct ledge over antennal socket. Pronotum short, broadly rounding in front. Elytra narrow, the lateral margins of abdominal segments exposed.

Of the three species that occur in North America, only one is common in the eastern United States.

1. *Oncometopia undata* (Fabricius)

Cicada undata Fabricius (1794, p. 32).

Cicada orbona Fabricius (1798, p. 520).

Proconia nigricans Walker (1851a, p. 783).

Proconia clarius Walker (1851a, p. 784).

Proconia lucerneae Walker (1851a, p. 785).

Proconia marginata Walker (1851a, p. 785).

Proconia badia Walker (1851a, p. 786).

Proconia scutellata Walker (1851a, p. 786).
Proconia tenebrosa Walker (1851a, p. 787).
Proconia plagiata Walker (1851a, p. 788).
Oncometopia alpha Fowler (1899, p. 232).

Fig. 132. Length 13 mm. Vertex roundedly right angled and two-thirds as long as basal width; color orange yellow, marked with an incomplete circle before the middle, open in front, and with light radiating lines; a marginal line from eye to apex. Anterior portion of pronotum and scutellum slate blue to black. Elytra brownish or reddish, apex distinctly lighter than basal region; anterior margins of elytra in female sometimes with a rounded granulate exudation. Female seventh sternite with posterior margin forming three equal rounded lobes. Male plates short, half the length of seventh sternite.

A species common in pastures on ironweed, *Vernonia* sp., and similar rank growth in weedy areas, *undata* is distributed throughout the eastern United States and occurs westward to Texas and North Dakota.

Illinois Records.—Many males and females, taken May 12 to November 7, are from Aledo, Algonquin, Allerton, Alto Pass, Anna, Ashley, Belleville, Cairo, Carbondale, Cave in Rock, Centralia, Champaign, Clay City, Cobden, Dix, Dixon Springs, Dolson, Dubois, East St. Louis, Edwardsville, Eic-

horn, Elizabethtown, Fountain Bluff, Golconda, Goreville, Grafton, Grand Tower, Havana, Herod, Homer, Hookdale, Jonesboro, Kampsville, Kankakee, Karnak, Mahomet, Mascoutah, Momence, Mound City, Muncie, Murphysboro, Nashville, Norris City, Oakwood, Olive Branch, Olney, Pana, Pankeyville, Parker, Pine Hills, Posey, Pulaski, Rago, Richview, Seymour, Shawneetown, Springfield, Urbana, Waltersburg, White Heath, Wolf Lake, and York.

12. *HOMALODISCA* Stål

Homalodisca Stål (1869, pp. 60, 63).

Figs. 126, 128. Vertex and pronotum deflexed, vertex triangular, wider than pronotum, and with large prominent eyes; vertex forming an acute angle with front, which appears straight or flat when viewed laterally. Pronotum quadrangular.

Five species of this genus are known to occur in North America. Four of them are confined to the Southwest and one is found in the southern states, where it occurs from South Carolina to Arkansas and Texas. Since the state of Illinois extends southward to the junction of the Ohio and Mississippi rivers, and cotton is commonly grown in this area, it may be that *Homalodisca triquetra*, which is a common pest of cotton in the South, will be found in this area at some future time.

1. *Homalodisca triquetra* (Fabricius)

Cicada triquetra Fabricius (1803, p. 63).
Tettigonia vitripennis Germar (1821, p. 61).
Tettigonia coagulata Say (1832, p. 13).
Proconia excludens Walker (1851b, p. 98).
Tettigonia ichthycephala Signoret (1854, p. 494).
Proconia admittens Walker (1858, p. 227).
Proconia aurigena Walker (1858, p. 228).

Length 13 mm. Elongate, with triangular head, which is strongly produced and bluntly angled. Vertex as long as width between eyes at base and slightly longer than pronotum; disc flat, sloping to a median furrow. Vertex, pronotum, and scutellum dark brown, finely and irregularly irrorate with yellow. Elytra each subhyaline, tinged with brown, a broad pale transverse band before middle, and a reddish spot before apical cells that extends anteriorly along the costa. Face and venter orange yellow. Female seventh sternite elongate, with produced lateral angles, between which the posterior margin is rather widely and deeply exca-

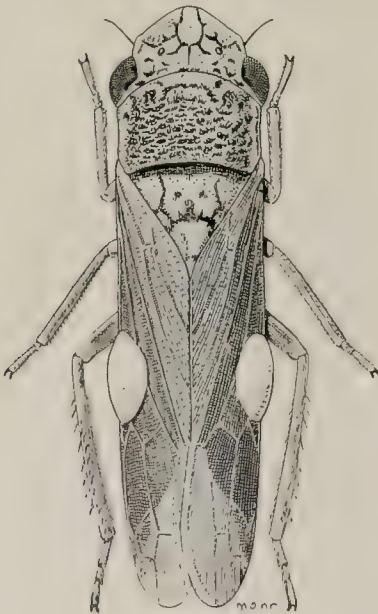


Fig. 132—*Oncometopia undata*.

vated; male plates triangular, one-third longer than basal width, apices acutely angled.

This species is distributed throughout the southeastern United States and is known to occur as far west as Texas.

13. *CIMINIUS* Metcalf & Bruner

Ciminius Metcalf & Bruner (1936, p. 944).

Related to *Kolla*. Vertex triangular, broader than long; the anterior margins continuing from the margins of the eyes; the dorsal surface sloping to meet the slightly inflated face.

1. *Ciminius hartii* (Ball)

Tettigonia hartii Ball (1901, p. 61).

Length 3.75–5.0 mm. Short and robust, with dimorphic sex colors; female grayish brown, male shiny black. Vertex twice as wide as long. Female with ocelli and a pair of spots behind them black; anterior part of vertex darker, with a light spot at apex; pronotum brown, anterior margin yellowish, a dark spot behind either eye; basal angles of scutellum black; elytra gray, nervures yellowish, claval margins pale blue. Male with white spot on apex of vertex; pale circles around ocelli and at apex of scutellum.

Female seventh sternite with truncate posterior margin bearing a median tooth formed by an incision on either side of center. Male plates very short, triangular, apices blunt.

The species occurs in pasture and meadow areas and has been taken in the *Aristida gracilis* habitat. It is distributed rather abundantly through the eastern United States and occurs as far west as Texas and New Mexico.

Illinois Records.—Males and females, taken June 14 to October 2, are from Alton, Carbondale, Cave in Rock, Centralia, Cobden, Dubois, Hardin, Herod, Marshall, Metropolis, Pike, Springfield, and Vienna.

14. *KOLLA* Distant

Kolla Distant (1907, p. 223).

Fig. 122. Vertex subconically narrowed anteriorly, lateral margins in line with corresponding margins of eyes. Face with lateral areas somewhat strongly and transversely striate. Antennae long.

Two species are recorded in this genus

for the United States, and both occur in Illinois.

KEY TO SPECIES

- Length at least 5.5 mm.; nervures of elytra broad and black. 1. *bifida*
Length not exceeding 5.0 mm.; elytra dark green, without broad black nervures. 2. *geometrica*

1. *Kolla bifida* (Say)

Tettigonia bifida Say (1831, p. 313).

Tettigonia tenella Walker (1851a, p. 770).

Fig. 133. Length 5.5–6.0 mm. Green, with white transverse bands on head and pronotum, nervures of elytra black. Vertex



Fig. 133.—*Kolla bifida*.

bluntly conical, short, almost twice as wide as long, black; two white spots at apex, a transverse white band across disc, and another on posterior margin. Face black. Pronotum margined with a black band anteriorly, posterior margin white, with a black band just anterior to it; disc green. Elytra green, nervures black, apices smoky. Female seventh sternite with posterior margin roundedly produced at middle. Male plates short, triangular, apices slightly produced.

A common meadow and pasture species, especially abundant on coarse grasses in moist areas, *bifida* is distributed throughout

the eastern states and occurs as far west as Kansas and Nebraska.

Illinois Records.—Many males and females, taken June 14 to October 20, are from Aldridge, Algonquin, Alton, Apple River Canyon State Park, Carbondale, Cave in Rock, Channel Lake,*Clay City, Dolson, Dongola, Dubois, Elizabethtown, Fern Cliff, Fountain Bluff, Grafton, Grand Detour, Grand Tower, Herod, Kampsville, Kankakee, Karnak, Lima, Metropolis, Mount Carmel, Muncie, Newton, Oak Lawn, Oakwood, Quincy, Rock Island, Savanna, Shawneetown, Urbana, Valley City, Vienna, Watson, and White Heath.

2. *Kolla geometrica* (Signoret)

Tettigonia geometrica Signoret (1854, p. 12).
Tettigonia psittacella Fowler (1900, p. 290).

Length 4.5–5.0 mm. In general appearance similar to *bifida* but smaller; elytra without black nervures. Vertex black, marked with two apical spots and two transverse bright yellow bands as in *bifida*. Face black. Pronotum and scutellum marked as in *bifida*. Elytra bright green, nervures faintly black, apexes smoky; each with three light spots anterior to smoky area and costal margin. Female seventh sternite with rounded posterior margin. Male plates short, triangular.

A common pasture and meadow species, especially in moist areas, *geometrica* is distributed in the southern states from the District of Columbia to Arkansas and Missouri.

Illinois Records.—Males and females, taken May 7 to September 24, are from Alto Pass, Dixon Springs, Dolson, Fern Cliff, Herod, Jonesboro, Karnak, Ozark, Rago, Urbana, and Vienna.

15. *HELOCHARA* Fitch

Helochara Fitch (1851, p. 56).

Fig. 131. Head wider than thorax, much broader than long, slightly and obtusely angled, and conical. The reflexed portion of the front elevated and prominent. Profile of face convex. Pronotum very long, hexangular, resembling the pronotum of *Aulacizes*; lateral margins short. Scutellum very small. Each elytron coriaceous, veins distinct, raised, with three anteapical and five apical cells.

Two species belonging to the genus are known in North America. One of them is

known only from California. The other is common throughout most of the United States.

1. *Helochara communis* Fitch

Helochara communis Fitch (1851, p. 56).
Tettigonia herbida Walker (1851a, p. 769).

Length of female 6.0–7.0 mm.; male 4.0–5.5 mm. Usually dark green, but often pale green or yellowish, with a dark green stripe along claval suture. Eyes, ocelli, and concentric lines on reflexed portions of front dark. Male face black, female face green, marked with black arcs. The vertex is obtusely angled, blunt on margin, the reflexed portion of front prominent on vertex. Female seventh sternite with posterior margin slightly produced at middle. Male plates triangular, finger-like. Each antenna of male enlarged toward apex, fig. 131.

This is a very common species and probably the one taken most abundantly along stream margins, in low marshy grasses, or in wet meadows. It is transcontinental in distribution.

Illinois Records.—Many males and females, taken May 10 to October 17, are from Algonquin, Apple River Canyon State Park, Atlas, Beach, Cave in Rock, Fox Lake, Freeport, Fulton, Galena, Havana, Harvard, Momence, Mount Carmel, Oak Lawn, Oquawka, Palos Park, Princeton, Rock Island, Sheffield, Spring Grove, Sun Lake, Urbana, and Volo.

16. *CARNEOCEPHALA* Ball

Carneocephala Ball (1927, p. 39).

Fig. 125. Resembling *Draeculacephala* in general appearance and in the character of the reticulate apical portion of the elytra but differing by having the front inflated and conically rounded to the vertex. The vertex lacks the definite margin found in *Draeculacephala*; front mottled with tawny. Pronotum long, inclined to be hexangular.

Eight species are recorded by Nottingham (1932) and Knull (1940) as occurring in the United States; two of these occur in the East. Only one is known from Illinois.

1. *Carneocephala flaviceps* (Riley)

Diedrocephala flaviceps Riley (1880, p. 78).

Length of female 5.0–6.0 mm., male 4.5–5.0 mm. Dull greenish, elytra conspicuously

marked by white veins, apexes pale gray or smoky, reticulate veined. Vertex bluntly angled, fulvous, marked with white. Pronotum yellowish anteriorly, disc green. Face fulvous tinted with pink. Female seventh sternite with a broad slightly produced median lobe. Male plates broad, gradually tapered to rather blunt apexes, each bearing a finger-like process.

A common grass-feeding species, *flaviceps* occurs throughout the southern United States and is distributed from coast to coast. Although it is known in Illinois only in the southern part, there are records of its occurrence in Wisconsin.

Illinois Records.—CAVE IN ROCK: Oct. 2, 1934, Ross, 4♂, 2♀. DIXON SPRINGS: July 29, 1934, DeLong & Ross, 2♂, 1♀. HARRISBURG: at light, June 15, 1934, DeLong & Ross, 1♀; Aug. 3, 1934, DeLong & Ross, 1♂, 1♀. HORSESHOE LAKE: at light, July 10, 1933, Ross & DeLong, 2♂, 1♀. LAWRENCEVILLE: Sept. 7, 1933, Ross & Mohr, 1♀. METROPOLIS: Aug. 20, 1916, 2♂, 4♀. VIENNA: June 14, 1934, DeLong & Ross, 1♂, 3♀; Aug. 3, 1934, DeLong & Mohr, 2♂.

17. *GRAPHOCEPHALA* Van Duzee

Graphocephala Van Duzee (1916, p. 66).

Fig. 116. Head narrower than pronotum, eyes small, vertex almost flat, roundedly angled, apex obtusely rounded, margin sharp, acute, and dark lined. Front broad, appearing flat above in profile. Pronotum broadest across lateral angles, strongly curved in front, the side margins continuous with the curve of anterior margin. This genus contains some highly colored species that can be distinguished readily from the related *Ciminius* by the dark marginal band on the vertex.

Four species are known to occur in the United States; two of them are confined to the Southwest and two occur in the eastern states. One is northern and the other is southern in distribution, and both are found in Illinois.

KEY TO SPECIES

Vertex yellow, with a black band on anterior margin; length 8 mm. or more.

1. *coccinea*

Vertex yellow, a black line just back of margin and parallel to it, and a pair of proximal longitudinal lines on disc; length 6 mm. or less.

2. *versuta*

1. *Graphocephala coccinea* (Forster)

Cicada coccinea Forster (1771, p. 69).
Tettigonia quadrivittata Say (1831, p. 312).
Tettigonia picta Walker (1851a, p. 758).

Length 8-9 mm. Pronotum and elytra red, marked with green longitudinal stripes; a broad median stripe on posterior portion of pronotum and a pair of oblique green stripes from the humeral angles. Elytra red; with claval suture, costal margin, a median stripe on corium, and the sutural margin before the middle of each green. Face and vertex yellow, a broad black band just beneath margin of vertex. Scutellum yellow. Female seventh sternite with posterior margin produced and rounded. Male plates long, concavely narrowed, attenuate, apexes acute.

This is one of the largest, most conspicuously marked, and most common species of the North American leafhopper fauna. It usually occurs in abundance upon *Rubus* and is frequently found in all stages upon certain species of ornamental shrubs such as *Forsythia*. It often occurs in sufficient numbers to cause economic injury to ornamental plants. It is distributed throughout the eastern United States and occurs as far west as Texas and Oklahoma.

Illinois Records.—Many males and females, taken June 1 to October 21, are from Algonquin, Anna, Antioch, Apple River Canyon State Park, Atlas, Bluffs, Borton, Channel Lake, Chicago, Dixon, Dixon Springs, Dolson, Dubois, Eichorn, Elizabethtown, Galena, Galesburg, Golconda, Grafton, Grand Detour, Grandview, Grand Tower, Hardin, Harrisburg, Harvard, Havana, Herod, Homer, Justice, Kankakee, Keithsburg, Karnak, La Grange, Lawrenceville, Mahomet, Monticello, Mound City, Mount Carmel, Muncie, New Milford, Newton, Normal, Oakwood, Oregon, Palatine, Palos Park, Pulaski, Putnam, Quincy, Rock Island, Rosiclare, Savanna, Shawneetown, Starved Rock State Park, Temple Hill, Urbana, Vienna, Villa Ridge, Volo, Warren, Warsaw, Watson, Wauconda, White Heath, and White Pines Forest State Park.

2. *Graphocephala versuta* (Say)

Tettigonia versuta Say (1831, p. 311).
Tettigonia redacta Fowler (1900, p. 276).

Length 5-6 mm. Similar in color markings to *coccinea* but smaller in size. Vertex yellow, a black stripe on front just below

margin, a pair of median proximal black lines joined anteriorly with a pair of oblique black lines, which are almost parallel with anterior margins. Pronotum yellow at apex and along sides, and green posteriorly. Scutellum yellow or reddish, with black longitudinal lines. Elytron green or blue, a red stripe on either side of a blue stripe on claval suture; apical margin and posterior portion of costa pale yellow, with dark spots around apex. Female seventh sternite with posterior margin angularly produced, concave laterally. Male plates concavely narrowed to pointed apices, which are dark at tips and slightly turned up.

This species is especially abundant in the southern United States and occurs in southern Illinois and as far west as Texas. It is usually found in grassy and other types of herbaceous vegetation.

Illinois Records.—Many males and females, taken May 7 to November 13, are from Alto Pass, Anna, Anvil Rock, Borton, Browns, Cache, Carbondale, Carmi, Cave in Rock, Chester, Dixon Springs, Dongola, Dubois, Eichorn, Elizabethtown, Fountain Bluff, Gibsonia, Golconda, Grand Tower, Harrisburg, Herod, High Knob, Homer, Jonesboro, Karbers Ridge, Karnak, Makanda, Marshall, Metropolis, Mount Carmel, Norris City, Pounds, Pulaski, Quincy, Rosiclare, Shawneetown, Thebes, Urbana, Valley City, Vienna, Villa Ridge, Watson, Wichert, and White Heath.

18. *Plesiommata* Provancher

Plesiommata Provancher (1889, p. 263).

Fig. 119. Slender, elongate in form. Vertex strongly produced and bluntly angled, more than two-thirds as long as basal width between eyes. Ocelli equidistant between posterior and lateral margins of vertex. Dorsal surface of vertex not deflexed, anterior portion gently rounded to apex and bluntly angled with front.

Only two species are known in this genus. One is recorded from Arizona. The other, *tripunctata*, is eastern in distribution. It was described as belonging to *Tettigonia* by Fitch (1851) and referred to *Kolla* by Van Duzee (1912). Van Duzee (1917) placed it in *Pagaronia*, a genus of larger western species. Oman (1938b), in a revision of the tribe Errhomenellini, placed it in *Plesiommata*, a genus erected for it when it was redescribed by Provancher.

1. *Plesiommata tripunctata* (Fitch)

Tettigonia tripunctata Fitch (1851, p. 55).
Plesiommata biundulata Provancher (1889, p. 263).

Length 5 mm. White, marked with dark brown or black. Vertex conically pointed, with three black spots, one at apex and one enclosing each ocellus. Reflexed portion of face often marked with brown arcs. Margins of pronotum with brown lines, two transverse bands on disc. Elytral margins, nervures, and claval sutures with narrow brown lines. Posterior margin of female seventh sternite truncate or slightly rounded. Male plates broad at base, triangular, apices produced, forming attenuate tips.

A common species in open wooded areas on *Muhlenbergia* and similar herbaceous plants, *tripunctata* is distributed throughout the eastern United States and as far west as Missouri.

Illinois Records.—Males and females, taken February 1 to October 16, are from Aldridge, Apple River Canyon State Park, Dolson, Grand Tower, Herod, Normal, Thomson, Urbana, Vienna, and White Heath.

19. *Draeculacephala* Ball

Draeculacephala Ball (1901, p. 66).

Fig. 124. Vertex triangularly produced, bluntly pointed, frequently depressed just back of apex of vertex and flat or concave on anterior discal portion. Pronotum equaling width of head or narrower. Elytra long, narrowed apically, greenish, nervures raised, often paler, the apical and antepical cells irregularly reticulate veined. The vertex anterior portion of pronotum, and scutellum are usually a shade of yellow, and the disc of pronotum and the elytra are dark green. All the members of this genus are similar in color pattern.

These leafhoppers are found in meadows, marshes, and swamps and occur on grasses and sedges, usually in abundance. Fourteen species have been recorded for North America in the various revisions of Van Duzee (1915a), Ball (1927), and Ball & China (1933). Nine forms have been collected in Illinois.

KEY TO SPECIES

1. Anterior portion of pronotum with black or brown vermiculate markings. 2
- Anterior portion of pronotum pale yellow

- or green, without definite dark vermiculate markings. 3
2. Markings on vertex and pronotum black, prominent; males not exceeding 6 mm., females not exceeding 8 mm. in length. 1. *inscripta*
- Markings on vertex and pronotum usually brownish, not prominent; males at least 8 mm., females at least 10 mm. in length. 6. *portola* var. *pallidosa*
3. Vertex short in males; apex blunt, rounded margin thickened anteriorly; conspicuous black spots at apex and next to eyes. 4
- Vertex usually more angularly produced and acute; dark spots at apex small or faint, lines on vertex faint or narrow. 5
4. Male with a pair of black spots at apex of vertex and a spot just back of apex on meson. Female with vertex one-fourth wider than long, markings often faint. 2. *prasina*
- Male with a pair of black spots at apex and a spot next to each eye; median spot absent. Female with vertex almost as long as basal width, markings usually dark, conspicuous. 3. *angulifera*
5. Females. 6
- Males. 8
6. Length 9.0-10.0 mm. 7
- Length 7.5-8.0 mm. 7
8. *constricta* and 7. *mollipes*
7. Length 10 mm.; vertex about as long as basal width between eyes. 5. *portola* and 4. *producta*
- Length 9 mm.; vertex decidedly longer than basal width between eyes. 9. *antica*
8. Aedeagus with the ventral process of the dorsoposterior portion abruptly rounded from narrow basal stalk to form a rounded apical portion, as in figs. 148, 150. 9
- Ventral process not abruptly widened, more sloping, narrower and more elongate, as in fig. 143. 10
9. Aedeagus, fig. 148, with terminal portion as wide as long and subangulate on the sides near neck. 5. *portola*
- Aedeagus, fig. 150, with terminal portion longer than wide and nearly evenly rounded on sides between neck and apex. 4. *producta*
10. Apex of ventral process, fig. 143, narrowed and bluntly angled. 7. *mollipes*
- Apex of ventral process rounded and notched, as in figs. 147, 149. 11
11. Ventral process, fig. 149, appearing in ventral view narrowly notched either side near base, gradually widened from notch to apex, which is broadly rounded either side of a deep notch; long slender processes from ventroanterior portion straight, not curved at apex. 9. *antica*
- Ventral process, fig. 147, broadly, concavely rounded either side at base, widened on apical half, broadly rounded at apex, with a slight median notch; long slender processes from ventroanterior portion curved dorsally at apex. 8. *constricta*

1. *Draeculacephala inscripta* Van Duzee

Draeculacephala inscripta Van Duzee (1915a, p. 180).

Length of female 8 mm., male 6 mm. Short headed, with prominent black markings on vertex and anterior portion of pronotum. Vertex bluntly pointed, in both sexes decidedly wider between eyes than median length. Scutellum and anterior portion of pronotum yellow; disc of pronotum and elytra dark green; vertex with three broad curved black arcs between each eye and apex, a median black longitudinal line, a black oblique line anterior to median longitudinal line, a black oblique line anterior to and another posterior to ocellus, and a black spot between ocellus and eye. Pronotum one-fourth longer than vertex. Anterior portion marked with heavy black vermiculate lines. Scutellum with two round black spots on anterior portion of disc.

Posterior margin of female seventh sternite produced at median one-fourth with apex rounded, then concavely rounded on each side. Male plates rather long, triangular, gradually narrowed to rounded and upturned apices. Styles, fig. 144, elongate, each broad near base, narrowed toward apex, with apical fifth bent inward, sloping to pointed apex, which is turned upward. The ventroanterior part of aedeagus bears two pairs of processes; the dorsal pair medium in length and heavy, the ventral pair slender and long, almost enclosing remainder of aedeagus. The dorsoposterior portion also bears a pair of dorsally directed processes at base, and a ventral portion, which is about one-third as wide as long (in ventral view), narrow at base for about one-fourth its length, then rapidly broadened and rounded to a blunt produced apex. Pygofers as in fig. 136d.

This species is distributed throughout the southeastern states and has been found in southern Ohio and southern Illinois.

Illinois Records.—KARNAK: Aug. 8, 1934, Ross, DeLong, & Mohr, 2♀. NORRIS CITY: on *Jussiaea diffusa*, Sept. 9, 1933, Ross & Mohr, 12♂, 12♀.

2. *Draeculacephala prasina* (Walker)

Tettigonia prasina Walker (1851a, p. 768).
Aulacizes noveboracensis Fitch (1851, p. 56).

Length 8.0-8.5 mm. Blunt headed, with a pair of heavy black spots at apex of yellow vertex, and a black spot just in front of

each eye along margin, these spots usually larger in male than in female. Pronotum with anterior margin yellow, posterior portion dark green. Scutellum yellow, elytra green. Vertex bluntly angled, in male one-third wider between eyes than median length and decidedly shorter than pronotum. In female one-fourth wider between eyes than median length and about as long as pronotum.

Female seventh sternite long, with rather prominent lateral angles, between which the posterior margin is concavely rounded either side of a median produced apical fourth, the latter blunt at apex. Male plates appearing rather short and triangular, but each with blunt rounded upturned apex. Styles, fig. 145, long and narrow, each with the apical half curved dorsally and then caudally and sharp pointed at apex; ventroanterior portion of aedeagus with a pair of dorsally directed divergent processes and a pair of ventral processes that are curved outward, dorsally, and then caudally, enclosing the dorsoposterior portion of the aedeagus; the latter portion with a pair of dorsally directed processes and a ventral portion. The ventral portion is short and bears a pair of apical processes that are directed basad and are almost as long as the portion to which they are attached. Pygofer as in fig. 138*A*.

This is a common transcontinental species and is found in the United States from coast to coast.

Illinois Records.—Males and females, taken May 14 to October 5, are from Algonquin, Alsip, Amboy, Antioch, Champaign, Des Plaines, Fox Lake, Grand Detour, Ingleside, Lake Villa, McHenry, Moline, Orangeville, Savanna, Sun Lake, Waterman, Wauconda, Waukegan, and Zion.

3. *Draeculacephala angulifera* (Walker)

Tettigonia angulifera Walker (1851*a*, p. 771).
Draeculacephala manitobiana Ball (1901, p. 70).

Length of female 8.5 mm., male 7.5 mm. Large, yellow and green, with a short bluntly angled head and distinctive genitalia. Vertex in male distinctly wider between eyes at base than median length; in female slightly wider at base than median length. Vertex, anterior portion of pronotum, and scutellum yellow. Posterior half of pronotum and elytra dark green. Male with a black spot on either side of apex

of vertex from which arise four parallel marginal lines; large triangular black spot just back of apex, from the base of which a diagonal heavy black line extends to each ocellar suture; from each line a broad stripe branches, extends inside of ocellus; in female, spots on either side of apex are much smaller; four marginal parallel lines conspicuous; median brown line extends from near apex to base; the two oblique lines on each side are brown; the anterior line is anterior to the ocellus and the posterior line is mesad and posterior to the ocellus.

Female seventh sternite with posterior margin produced, sloping from lateral angles to form a bluntly angled apex, slightly excavated near the lateral angles on each side. Male plates triangular, each tapered from a rather broad base to a narrow pointed apex, and exceeded by pygofer, fig. 139*A*, which is almost twice as long as plate. The dorsoposterior portion of the aedeagus, fig. 146, with a pair of long processes arising at base; ventral process rather broad at base and bearing lateral spurs; process constricted near base and produced for two-thirds its length, then enlarged to form a terminal portion that bears a long process on each outer angle, which extends basally. The terminal portion is narrowed and blunt at apex.

This species ranges from Ontario and Manitoba to Colorado. It is rare in Illinois.

Illinois Records.—CEDAR LAKE: Aug. 6, 1906, 1 ♂, 2 ♀. CHAMPAIGN: at light, July 26, 1889, 1 ♂. LAKE VILLA: swamp, Aug. 9, 1906, 1 ♂, 4 ♀.

4. *Draeculacephala producta* (Walker)

Tettigonia producta Walker (1851*a*, p. 772).
Tettigonia acuta Walker (1851*a*, p. 773).
Tettigonia minor Walker (1851*a*, p. 772).
Draeculacephala cubana Metcalf & Bruner (1936, p. 926).

Length of female 10 mm., male 7 mm. Large, resembling *mollipes* in coloration and general appearance but with distinctive male genitalia. Vertex bluntly and angularly produced, in male wider between eyes than median length and much shorter than pronotum; in female as long as basal width between eyes and as long as pronotum. Vertex, anterior portion of pronotum, and scutellum yellow, the remainder of dorsal surface dark green. The vertex marked with faint brownish lines.

Female seventh sternite with posterior margin strongly produced and concave either side of blunt apex. Male plates long and each concavely narrowed to blunt acute apex. Styles, fig. 150, short, rather broad, apical half of each curved inwardly with apex bent ventrally; aedeagus with ventro-anterior portion bearing a pair of short dorsally directed processes and a pair of long curved divergent spinelike structures that extend to apex of aedeagus, converge near apex, and have a tip bent dorsally; dorsoposterior portion also has a pair of thick dorsally directed processes and a ventral process that in ventral view is narrow at base, broadly rounded at middle, and has apex broadly curved; ventral process about two-thirds as wide as long. Pygofer as in fig. 142.

This is a common species in Illinois and is also known from California, Washington, Colorado, and Florida.

Illinois Records.—Many males and females, taken from May 7 to November 4, are from Algonquin, Anna, Antioch, Anvil Rock, Apple River Canyon State Park, Arlington Heights, Atlas, Belvidere, Bloomington, Cache, Cairo, Carbondale, Carlyle, Cave in Rock, Champaign, Danville, Decatur, Dixon, Dolson, Dubois, East Cape Girardeau, East St. Louis, Elizabeth, Elizabethtown, Evergreen Park, Fountain Bluff, Fox Lake, Fulton, Geff, Gibsonia, Golconda, Grafton, Grand Detour, Gulfport, Hamilton, Hardin, Harrisburg, Harvard, Havana, Herod, High Knob, Homer, Horseshoe Lake, Jonesboro, Kampsville, Kankakee, Karnak, Luther, Macomb, Makanda, Manteno, Marshall, McHenry, Metropolis, Momence, Mount Carmel, Muncie, New Holland, New Milford, Norris City, Oak Lawn, Oakwood, Ogden, Olive Branch, Oquawka, Orangeville, Palos Park, Parker, Parker City, Pike, Princeton, Pulaski, Putnam, Quincy, Rosiclare, St. Joseph, Savanna, Shawneetown, Springfield, Spring Valley, Starved Rock State Park, Texas City, Thomson, Urbana, Vienna, Villa Ridge, Volo, Waltersburg, Watson, White Pines Forest State Park, Wolf Lake, and Zion.

5. *Draeculacephala portola* Ball

Draeculacephala portola Ball (1927, p. 35).

Length of female 9.5 mm., male 7.5 mm. In form and general appearance resembling

producta but with male genitalia different. Vertex rather well produced, in male as long at middle as basal width between eyes; in female a little longer at middle than basal width between eyes. Vertex, anterior half of pronotum, and scutellum yellow; vertex with a brown spot either side of apex, each spot merging with the inner of three parallel marginal brownish lines; median line and a pair of diagonal lines on disc brown; posterior half of pronotum dark green, elytra dark green with pale veins.

Female seventh sternite with posterior margin produced, gradually sloping from rounded lateral angles to form a broadly angled, bluntly pointed apex. Male plates long, narrow, triangular, exceeded in length by the pygofer. Aedeagus, fig. 148, similar to that of *producta* but having the ventral process of the dorsoposterior portion with the narrowed constricted neck portion longer, and expanded part beyond the narrowed portion more abruptly widened to form broad shoulders at the base, from which the sides slope to form the bluntly pointed apex; pygofer, as in fig. 137*d*, also broadly rounded and not constricted or narrowed before apices.

This species was described from Florida and is known from three localities in Illinois.

Illinois Records.—MUNCIE: cattail bog, April 7, 1937, D. T. Ries, 1 ♀. SPRING VALLEY: June 28, 1937, Ross & Burks, 1 ♀. URBANA: July 2, 1889, C. A. Hart, 1 ♀.

6. *Draeculacephala portola* var. *paludosa* Ball & China

Draeculacephala paludosa Ball & China (1933, p. 3).

Length of female 10–11 mm., male 8 mm. In general form resembling the typical *portola* but a little larger and with irregular dark vermiculate markings on the yellow anterior one-third of the pronotum. Predominant color dark green, the vertex and scutellum yellow; dark lines on vertex prominent. Male genitalia as in *portola*, fig. 148.

This form is widely distributed from the East Coast to the West Coast and occurs upon the river bulrush, *Scirpus fluvialis*, at the margin of fresh-water swamps and marshes.

Illinois Record.—BUDA: in swamp, July 12, 1937, Mohr & Burks, 1 ♀.

7. *Draeculacephala mollipes* (Say)

Tettigonia mollipes Say (1831, p. 312).

Length of female 7.5–8.0 mm., male 6.0 mm. Yellow and green, with acutely angled vertex and without conspicuous markings. Vertex produced, apex blunt, as long as or slightly longer than basal width and slightly longer than pronotum. Vertex, anterior portion of pronotum, and scutellum yellow, posterior portion of pronotum and elytra dark green. Vertex faintly marked with narrow brownish lines.

Female seventh sternite with posterior margin concavely and roundedly produced either side of a median produced rounded apex. Male plates long, each concavely tapered to a narrow rounded divergent apex. Styles, fig. 143, short, each rather broad at middle of apical portion, bent inwardly, and outer margin concavely rounded to pointed apex; ventroanterior portion of aedeagus with a pair of rather short thick dorsally directed processes and a pair of long spinelike ventral processes that diverge and extend caudally to tip of aedeagus, with their apices curved dorsally; dorsoposterior portion with a pair of dorsally divergent processes and a ventral process that in ventral view appears elongate, about one-third as wide as long, with narrow base and narrow bluntly pointed apex. Pygofer as in fig. 141A.

This is a widely distributed species throughout the United States.

Illinois Records.—Males and females, taken June 10 to October 6, are from Apple River Canyon State Park, Carmi, Dixon Springs, Dolson, Farina, Gulfport, Harrisburg, Herod, High Knob, Jonesboro, Karnak, Mount Carmel, Muncie, Norris City, Princeton, Shawneetown, Springfield, Temple Hill, Vienna, Watson, and White Heath.

8. *Draeculacephala constricta* Davidson & DeLong

Draeculacephala constricta Davidson & DeLong (1943, p. 193).

Fig. 134. Length of female 8.0 mm., male 6.5 mm. Resembling *mollipes* in size, form, and color but with distinctive male genitalia. Vertex produced and bluntly angled, in both sexes as long as basal width and slightly shorter than pronotum. Vertex, anterior portion of pronotum, and scutellum yellow,

vertex marked with faint brownish longitudinal lines. Posterior portion of pronotum and elytra dark green, veins paler.

Female seventh sternite produced at apex, bluntly pointed, and concave on either side

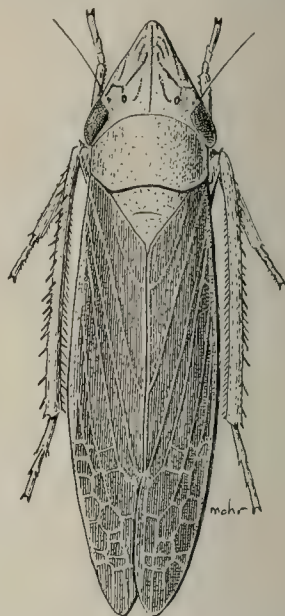


Fig. 134.—*Draeculacephala constricta*.

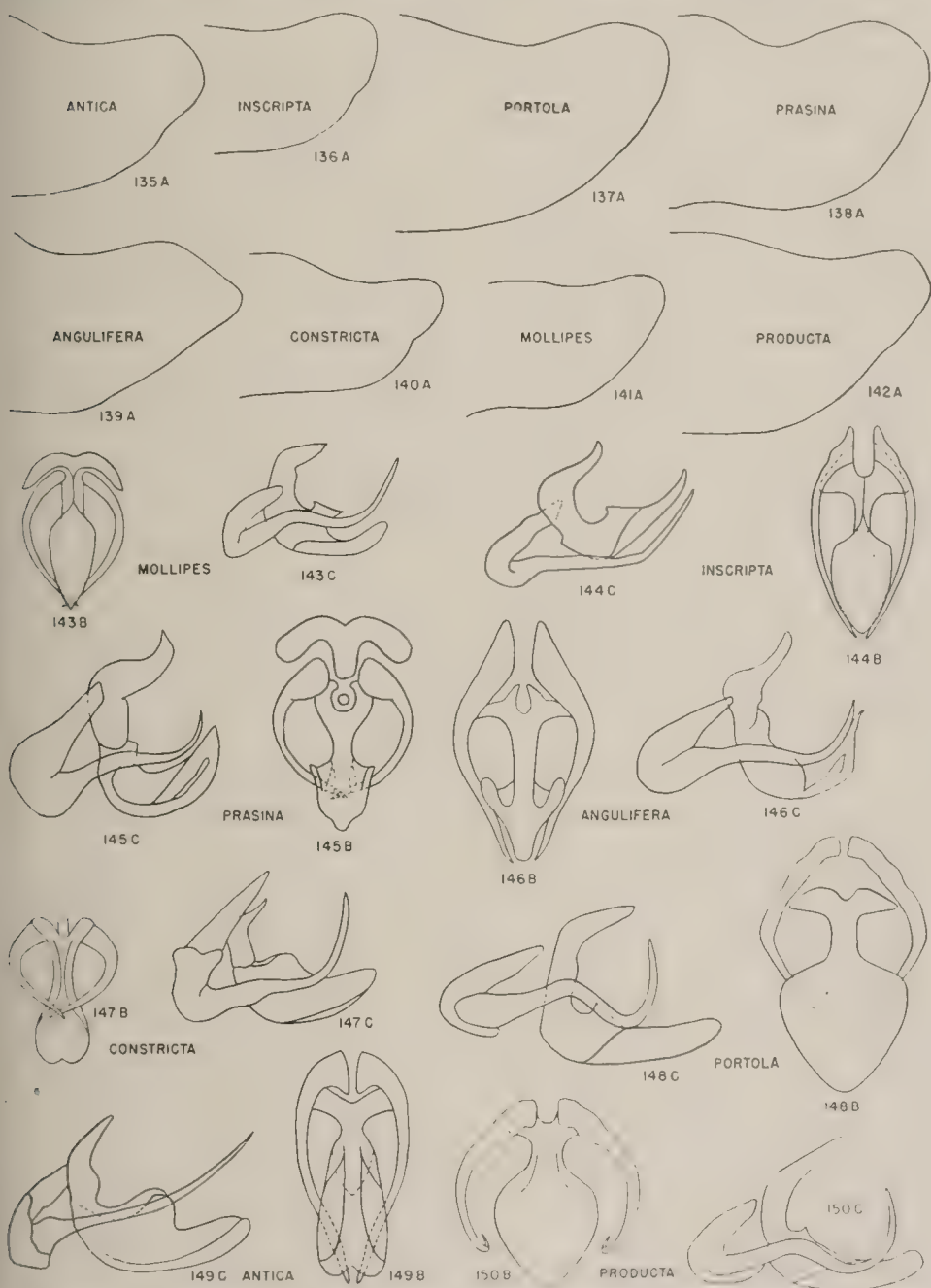
of apex. Male plates long, each reaching to tip of pygofer, concavely narrowed to acutely rounded apex. Styles, fig. 147, short, each broad at middle, apical portion bent inwardly, narrowed to pointed apex; ventroanterior portion of aedeagus with a pair of dorsally directed basal processes and a ventral pair of posteriorly directed divergent spinelike structures that extend almost to end of aedeagus and with apex that bends upward; dorsoposterior portion with a pair of dorsally directed processes and a ventral portion that is elongate, narrowed at base, convexly rounded in apical one-half and has apex broadly rounded; in lateral view ventral portion decidedly constricted just before base. Pygofer as in fig. 140A.

This species is found widely over the eastern and middle western states.

Illinois Records.—Many males and females, taken May 13 to November 3, are from Algonquin, Alton, Amboy, Anna, Antioch, Anvil Rock, Apple River Canyon State Park, Barry, Carbondale, Carmi, Cave in Rock, Champaign, Danville, Decatur, Dixon, Dixon Springs, Dolson, Dongola, Dubois,

Duncans Mills, Du Quoin, Evergreen Park, Fulton, Gibsonia, Grand Detour, Grand Tower, Grafton, Hanover, Havana, Homer, Kankakee, Kimmundy, Loda, Macomb, Marshall, McHenry, Metropolis, Monmouth,

Mount Carmel, Oak Lawn, Oakwood, Oquawka, Orangeville, Oregon, Parker, Pekin, Pike, Princeton, Pulaski, Putnam, Quincy, St. Anne, St. Joseph, Savanna, Seymour, Shawneetown, Sheffield, Springfield,



Figs. 135-150.—*Draculacephala*, male genitalia. A, pygofer; B, ventral aspect; C, lateral aspect.

Starved Rock State Park, Taylorville, Thomson, Urbana, Vienna, Wauconda, Waukegan, Weldon Springs, White Pines Forest State Park, and Zion.

9. *Draculacephala antica* (Walker)

Tettigonia antica Walker (1851a, p. 771).

Length of female 9 mm., male 7 mm. In general appearance resembling *mollipes* but with vertex more strongly produced and with distinctive male genitalia. Apex of vertex bluntly angled, in male slightly longer than basal width between eyes and as long as pronotum; in female decidedly longer than basal width between eyes and longer than pronotum. In color similar to *mollipes*; vertex yellow with faint brownish lines, anterior portion of pronotum and scutellum yellow, without markings.

Female seventh sternite with posterior margin concavely and roundedly produced to a median rounded produced apex. Male plates long, concavely rounded to acute rounded apices. Styles, fig. 149, rather short, apical half of each strongly sloping inwardly and narrowed to pointed apex that curves ventrally and slightly outwardly; ventroanterior portion of aedeagus with a pair of dorsally directed processes and a pair of ventral caudally directed spinelike structures that are as long as apex of aedeagus, divergent at base, converging near apex, and not bent dorsally; dorso-posterior portion with a basal pair of dorsally directed processes and a ventral portion that is narrow at base, broadened at middle, then tapered to a pair of blunt pointed processes at apex, this process elongate and about one-third as wide as long. Pygofers as in fig. 135A.

This species is found abundantly in the eastern United States.

Illinois Records.—Many males and females, taken May 4 to September 18, are from Adair, Albion, Amboy, Apple River Canyon State Park, Cache, Carbondale, Cary, Cave in Rock, Champaign, Des Plaines, Dixon, Dixon Springs, Dolson, Dongola, Elizabethtown, Fern Cliff, Fox Lake, Fulton, Grand Detour, Grand Tower, Havana, Herod, Homer, Jonesboro, Kankakee, Karnak, Litchfield, Monticello, Muncie, Normal, Oakwood, Oquawka, Pike, Princeton, Pulaski, Rago, St. Joseph, Taylorville, Thebes, Urbana, Vienna, Villa Ridge, Volo, Warren, and Wolf Lake.

20. *NEOKOLLA* Melichar

Neokolla Melichar (1926, p. 343).

Fig. 31. Head bluntly conical, slightly sloping, eyes and ledge over antennal sockets not prominent. Both front and vertex convex, merging without a perceptible margin separating them. Pronotum broadest at lateral angles. Elytra covering the tergum of abdomen.

Most species of *Neokolla* are known from the West or Southwest only. One is recorded from Quebec only. Two of the three eastern species are known to occur in Illinois. The other, a widely distributed species, may at some time be found in the southern part of the state.

KEY TO SPECIES

Black bars or lines, if present, on posterior portion of vertex, transverse; scutellum marked with black. 1. *hieroglyphica*
Black lines on posterior margin of vertex longitudinal; scutellum faintly marked. 2. *gothica*

1. *Neokolla hieroglyphica* (Say)

Tettigonia hieroglyphica Say (1831, p. 313).

Length 5.0–6.5 mm. This species varies in color from pale green and red to mostly black. The black form has been described as the variety *dolobrata* (Ball) (1901, p. 52), but some intergrades appear to connect the extremes. The lighter colored forms are blunt headed, stout, greenish through red to grayish, and with a black spot on apex of vertex; spot encircled by white; two divergent lines before middle not meeting at center; ocelli and a circle either side of disc at base black. Pronotum pale anteriorly, darker posteriorly, with light markings. Elytra slate, nervures darker. The darker variety is slightly smaller than typical *hieroglyphica*, shiny black in color except for margins of clypeus, genae, a line below the lateral margin of pronotum, circle around apex of vertex, line against each eye, and center of scutellum, which are white. Central line on vertex and line from this to either eye white; claval sutures of elytra light margined.

Female seventh sternite more than twice as long as sixth sternite; posterior margin triangularly produced, apex rounded. Male plates long, triangular.

This is a common willow species, and is especially abundant along the Illinois and

Mississippi rivers. The light and dark forms occur together in most collections.

Illinois Records.—Many males and females, taken March 29 to November 22, are from Adair, Alto Pass, Alton, Amboy, Anna, Ashley, Barry, Beardstown, Carbondale, Cave in Rock, Collinsville, Decatur, Dixon Springs, Dubois, East St. Louis, Eichorn, Elizabethtown, Fountain Bluff, Fulton, Geff, Grafton, Grand Tower, Greenville, Golconda, Hardin, Havana, Herod, Jonesboro, Kampsville, Karnak, Litchfield, Luther, Macomb, Mattoon, McHenry, Meredosia, Metropolis, Monticello, Neoga, New Columbia, Niota, Normal, Onarga, Oquawka, Pike, Princeton, Putnam, Quincy, Rockford, Rock Island, Rosiclare, St. Anne, Seymour, Shawneetown, Sheffield, Urbana, Vienna, Watson, West Union, White Heath, and White Pines Forest State Park.

2. *Neokolla gothica* (Signoret)

Tettigonia gothica Signoret (1854, p. 345).

Length 5.5–6.0 mm. Resembling *hieroglyphica* and often confused with it. Slightly smaller, vertex marked with several lines, which appear almost parallel. Vertex slightly conical, margins rounded, reddish or greenish yellow; apex black, surrounded by a pale circle; margins of reflexed portions, a line from this to ocellus, and a loop from the base either side light. Areas within these lines black. Scutellum light with dark markings. Elytra dirty green, nervures light. Female seventh sternite with posterior margin triangularly produced. Male plates long triangular.

This is a very common species in cut-over areas composed of shrubs and luxuriant growth of herbaceous vegetation. It is distributed throughout the eastern United States, and occurs as far west as Kansas and Texas.

Illinois Records.—Many males and females, taken March 29 to November 27, are from Aldridge, Alton, Alto Pass, Apple River Canyon State Park, Ashley, Bluffs, Champaign, Dixon Springs, Dolson, Dongola, Dubois, Elizabethtown, Galena, Grand Tower, Hardin, Havana, Herod, Mahomet, Marshall, Metropolis, Muncie, Murphysboro, Oakwood, Oliver, Oregon, Palos Park, Parker, Pike, Pounds, Quincy, Rock Island, Savanna, Urbana, Warren, Watson, White Heath, and White Pines Forest State Park.

21. *SIBOVIA* China

Sibovia China (1927, p. 283).

Fig. 118. Vertex blunt, with margins convex from eye to apex. Antennae at least half as long as body. Head and pronotum with a median and two pairs of narrow diagonal dark stripes.

One species in this genus is recorded for the United States.

1. *Sibovia occatoria* (Say)

Tettigonia occatoria Say (1831, p. 311).

Tettigonia compta Fowler (1900, p. 271).

Length 6 mm. Long and narrow, yellow, marked with black longitudinal lines. Vertex flat, bluntly angled, as long as basal width; yellow, a black spot at apex below the margin; a black stripe arising above and on either side of this spot and extending across vertex and pronotum, and a pair of black stripes inside and parallel to them meeting on anterior part of pronotum. A median dark brown line arising at base of vertex and extending to apex of scutellum. Elytra yellow, each marked with three black stripes on corium and three on clavus; apex black. Female seventh sternite with posterior margin obtusely rounded. Male plates short, rather broad, triangular, apices somewhat produced.

This species occurs on herbaceous vegetation in areas where luxuriant growth is found. It is known to occur from North Carolina and Florida to Texas and may eventually be collected in southern Illinois.

Subfamily EVACANTHINAE

This group is characterized by having the ocelli just above anterior margin of vertex, and a median longitudinal carina on the face and vertex. Another carina extends from the inner margin of eye to the middle of anterior margin of vertex.

Only one genus, *Evacanthus* Le Peletier & Serville, belongs in this subfamily.

22. *EVACANTHUS* Le Peletier & Serville

Evacanthus Le Peletier & Serville (1825, p. 612).

Fig. 30. Head short and broad, vertex blunt, wider between eyes than median length, with a central longitudinal keel and a branch of keel each side from apex to eye.

Ocelli just above marginal keel and proximal to margin and not close to eyes. Front inflated, longitudinally carinate. Elytra without anteapical cells.

Only two species of the genus are known to occur in North America. One is confined to certain regions of the southeastern states, and the other occurs in Canada and across the northern portions of the United States.

1. *Evacanthus acuminatus* (Fabricius)

Cicada acuminata Fabricius (1794, p. 36).

Cicada interstincta Fallen (1826, p. 29).

Amblycephalus germari Curtis (1833, p. 192).

Evacanthus orbitalis Fitch (1851, p. 57).

Fig. 151. Length 5.5–6.5 mm. Robust, with very blunt head and rather short elytra. Abdomen in female extending beyond apex

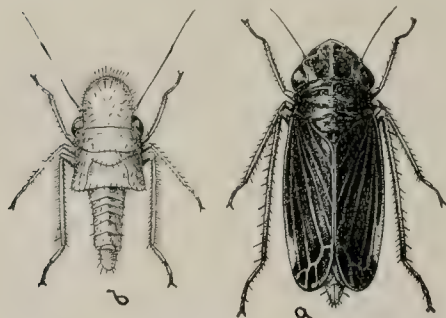


Fig. 151.—*Evacanthus acuminatus*: a, adult; b, nymph. (From Osborn.)

of elytra. Vertex with a median carina and also a carina extending from apex to either eye. Pronotum short, pubescent. Face and venter black. Female mostly testaceous on vertex and pronotum. Vertex with two black spots on disc and a row of spots on anterior portion of pronotum. Scutellum with two spots on disc. Elytra black or dark brown, with white stripes. Pubescence along nervures sparse. Female seventh sternite truncate or slightly sinuate. Male plates very long and slender, curved dorsally.

This species has been found on herbaceous vegetation in moist woodlands in the fern association.

Illinois Record.—URBANA: June 13, 1889, Hart, 1♂.

Subfamily PENTHIMIINAE

The short ovate body with distinctly depressed vertex and broadly overlapping fore-

wings at the apex characterize members of this group.

One genus only, *Penthimia*, belongs to this subfamily.

23. *PENTHIMIA* Germar

Penthimia Germar (1821, pp. 38, 46).

Fig. 152. Short, broad, ovate, well rounded anteriorly and posteriorly. Vertex broad, short, broadly rounded. Head, including eyes, narrower than pronotum. Pronotum rather long, distinctly and transversely striate. Body broad, very short, elytra exceeding abdomen in length; slightly more than twice as long as wide, apex of each clavus truncate, appendix broad.

Lawson (1933) records two species for the United States. One of them is known only from Florida. The other occurs in the northern United States and is distributed through the East and westward to Colorado.

1. *Penthimia americana* Fitch

Penthimia americana Fitch (1851, p. 57).

Penthimia vicaria Walker (1851a, p. 841).

Penthimia picta Provancher (1872, p. 352).

Fig. 152. Length 5–6 mm. Short, broadly oval, in general appearance resembling a cercopid, reddish brown to black in color, with minute brown spots. Female seventh sternite slightly notched either side on posterior margin, forming a median lobe. Male plates broad, triangular.

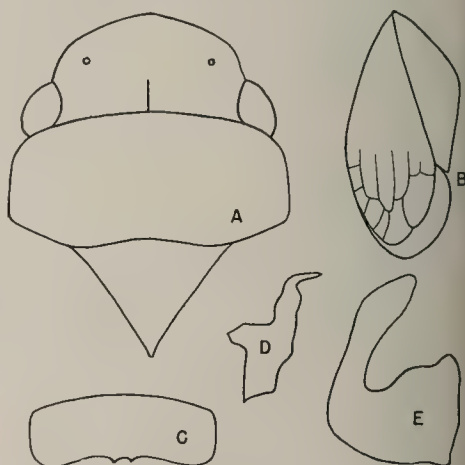


Fig. 152.—*Penthimia americana*. A, head and pronotum; B, elytron; C, female seventh sternite; D, E, male genitalia.

This species is widely distributed but not abundant and seems to be associated with shrubs in wooded and cut-over areas. It has frequently been taken from oak.

Illinois Records.—DUBOIS: May 21, 1917, 1♂; Aug. 10, 1917, 4♂. MAHOMET: June 30, 1912, 1♀. MEREDOSIA: May 29, 1917, 1 nymph. MUNCIE: May 27, 1905, 1♀. NORTHERN ILLINOIS: June, 1♀. OREGON: June 21, 1917, 1♀. SAVANNA: June 11, 1917, 1♀; June 12, 1917, 1♂. URBANA: in woods, May 7, 1888, 1♀; May 27, 1890, Hart, 1♀.

Subfamily GYPONINAE

The members of this group are elongate, dorsoventrally flattened, and with ocelli on disc of vertex. Hind wings each with four apical cells.

This subfamily was monographed by DeLong (1942). Representatives of 5 of the 11 genera now recognized as belonging to this subfamily occur in Illinois. The other genera are chiefly southwestern.

KEY TO GENERA

1. Elytra with numerous reticulate veins, at least on apical portions.....2
Elytra without numerous reticulate veins.....3
2. Elytra rugose or roughened, often with white mottling; vertex and pronotum usually rugose.....26. *Rugosana*
Elytra with venation often prominent but not rugose or roughened; vertex and pronotum never rugose.....
3. Vertex angled with front, margin thin, sharp, or foliaceous.....4
Margin of vertex thick, not foliaceous.....
4. Dorsal surface dull; head and pronotum peppered with small brown dots; vertex with three longitudinal furrows, the ocelli situated at an angle on the lateral ones; cells of elytra margined with small dots.....27. *Prairiana*
Dorsal surface shiny and uniformly colored, or with head, pronotum, and scutellum darker than elytra; vertex without three distinct longitudinal furrows.....24. *Gypona*

24. *GYPONA* Germar

Gypona Germar (1821, p. 73).

Pronotum broader than vertex, and together usually sloping from posterior margin of pronotum to anterior margin of vertex, the latter with margin thin and foliaceous. Venation of elytra simple. The species of the genus frequently exhibit sexual dimorphism in size and color. Each of the females and the males, when light in color, usually has a round black dot on the pronotum behind each eye. The males are often black and the spots are obscured. The male styles are usually broadened on apical portions and truncate.

Eight species of this genus are recorded for the United States. One is known to occur in Illinois; the others are western or southwestern in distribution.

1. *Gypona melanota* Spangberg

Gypona melanota Spangberg (1878b, p. 19).

Gypona dorsalis Spangberg (1878b, p. 30).

Gypona bipunctulata Woodworth (1887, p. 30).

Gypona nigra Woodworth (1887, p. 31).

Fig. 153. Length of male 9.0 mm., female 11.5 mm. Broadly rounded vertex; sexual dimorphic coloration. Vertex twice as broad between eyes as median length. Pronotum much wider than vertex and more than twice as long. Female yellowish, with a small conspicuous black spot on each side

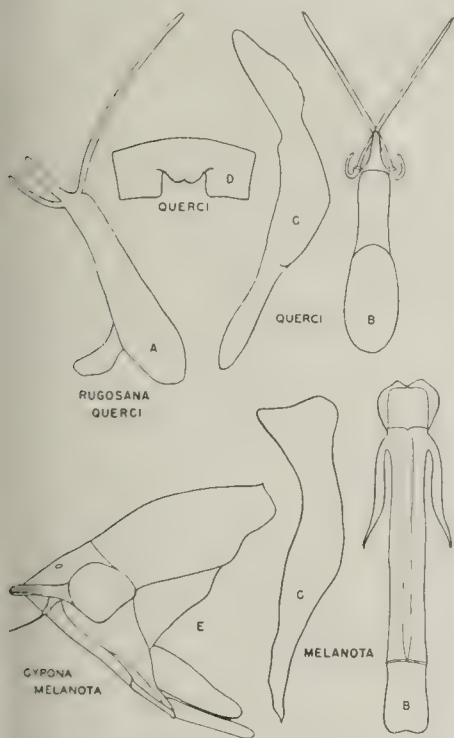


Fig. 153.—Gyponinae. A, lateral view of aedeagus; B, ventral view of aedeagus; C, style; D, female seventh sternite; E, head.

of outer disc of pronotum; elytra often greenish or appearing smoky. Male partially or entirely shiny black. The spots on pronotum conspicuous unless the entire pronotum is black.

Female seventh sternite broadly, angularly excavated from the produced lateral angles to form a rather broad shallow notch. Each male style somewhat narrowed between middle and broadened apical portion, which is broadly truncate on outer margin toward apex and rounded to apex on inner margin. Aedeagus broad, constricted before apex and produced and broadened to form an apical flap; just before the constriction a pair of lateral processes arise and extend basally for one-third the length of the body of the aedeagus.

This species is distributed from the New England states west to Colorado and Idaho. It occurs on low shrubs in cut-over areas and in open woodland.

Illinois Records.—CHAMPAIGN: July 27, 1892, Huckle, 1 ♀. OAK LAWN: July 27,

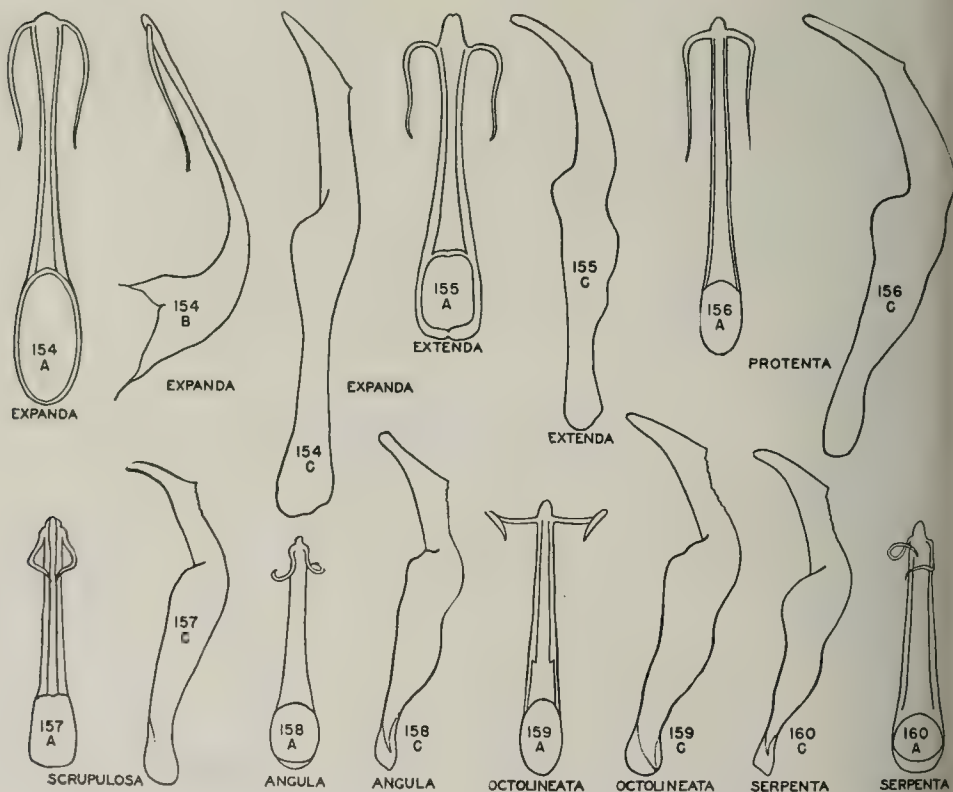
1934, DeLong & Ross, 3 ♂, 4 ♀; Sept. 6, 1935, Frison, 1 ♀. SAVOY: July 18, 1889, Hart, 1 ♂. SUMMIT: Aug. 21, 1935, DeLong & Ross, 1 ♀. TOLONO: July 25, 1895, 1 ♂.

25. *GYPONANA* Ball

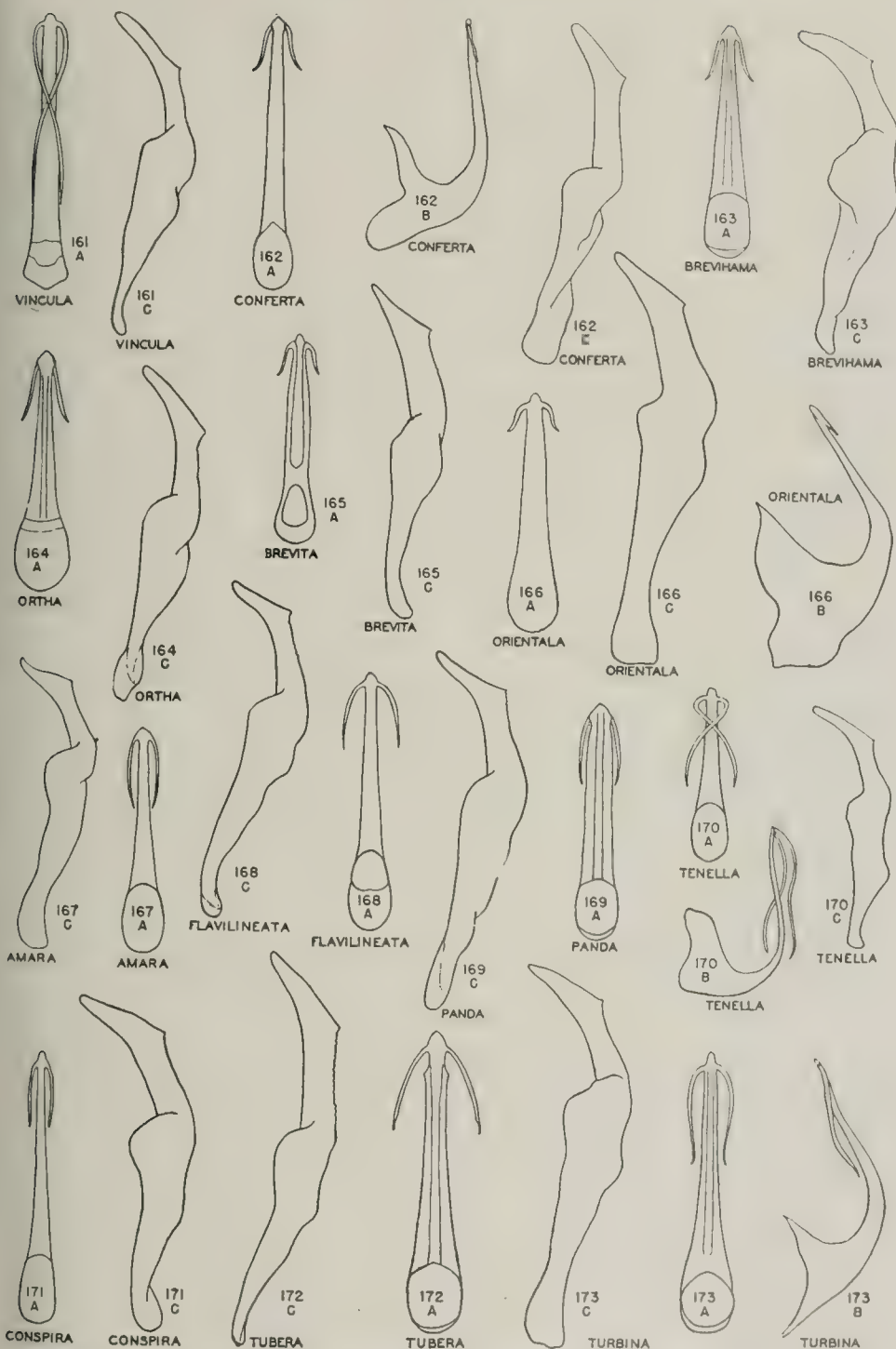
Gypsonana Ball (1920, p. 84).

Closely related to *Gypsona*. Vertex broad, flattened, and with the margin foliaceous and acutely angled with front. Pronotum broad, transverse, striated. Elytra rather long and narrow, with many irregular reticulations, especially on the apical portions.

Nearly 70 species of *Gypsonana* have been recorded for the United States; of these, 19 species and a variety are known to occur in Illinois. With few exceptions they are similar in appearance. The males may be distinguished by characters of the internal genitalia, but no satisfactory characters have been found for separating the females.



Figs. 154-160.—*Gypsonana*, male genitalia. A, ventral aspect of aedeagus; B, lateral aspect of aedeagus; C, style.



Figs. 161-173.—*Gyponana*, male genitalia. A, ventral aspect of aedeagus; B, lateral aspect of aedeagus; C, style.

KEY TO SPECIES

1. Males.....2
Females.....21
2. Aedeagus with rather short terminal processes, the apical halves of which are curved, twisted, or looped upon themselves as in figs. 157, 158.....3
Aedeagus with terminal processes of various lengths, but usually not twisted or looped upon themselves, as in figs. 155, 165.....6
3. Apical portion of each style, fig. 157C, beyond the heel or spine rather narrow, almost parallel margined and curved anteriorly.....17. **scrupulosa**
Apical portion of each style beyond the heel or spine broader and more gradually tapered to apex, as in figs. 158C, 159C.....4
4. Apical portion of each style, fig. 158C, appearing concave on both anterior and posterior portions beyond heel or spine.....20. **angula**
Apical portion of each style appearing concave on anterior margin only, as in figs. 159C, 160C.....5
5. Anterior margin of apex of each style, fig. 159C, slightly concave.....18. **octolineata**
Anterior margin more strongly concave, fig. 160C.....19. **octolineata** var. **serpenta**
6. Terminal processes of aedeagus one-fourth or less the length of shaft, as in fig. 165A.....7
Terminal processes of aedeagus longer, one-third or more the length of aedeagus shaft, as in fig. 155A.....11
7. Terminal aedeagus processes less than one-fifth the length of shaft.....8
Terminal aedeagus processes about one-fourth the length of shaft.....9
8. Each style, fig. 165C, slightly concave between spine and apex, the apex sharply pointed.....5. **brevita**
Each style, fig. 166C, not concave between spine and apex, the apex more bluntly pointed.....6. **orientala**
9. Apical portion of each style, fig. 171C, broad at spine, tapered to one-third its width at apex.....8. **conspira**
Apical portion of each style with blunt rounded apex, less strongly tapered to apex.....10
10. Apical portion of each style, fig. 163C, concavely curved anteriorly, convexly curved posteriorly between spine and apex.....3. **brevihama**
Apical portion of each style, fig. 162C, almost straight on anterior and posterior margins between spine and apex.....2. **conferta**
11. Terminal aedeagus processes extending laterally, then curved at right angles and extending basally, as in fig. 155A.....12
Terminal aedeagus processes curving basally from shaft, as in fig. 154A.....13
12. Aedeagus shaft, fig. 155A, broadened where terminal processes arise a short distance from apex; apical portion of style, fig. 155C, narrow and curved.....15. **extenda**
Aedeagus shaft, fig. 156A, not widened at point where terminal processes arise; apical portion of each style, fig. 156C, straight and narrow.....16. **protenta**
13. Apex of aedeagus, fig. 154A, decidedly widened and broadly rounded.....14. **expanda**
Apex of aedeagus not strongly widened.....14
14. Apex of each style bent caudally, fig. 167C.....11. **amara**
Apex of each style not bent caudally.....15
15. Apical portion of each style narrow, as in fig. 169C, appearing almost parallel margined just before apex.....16
Apical portion of each style sloping from spine to apex, not appearing parallel margined, as in figs. 172C, 173C.....20
16. Aedeagus shaft broad throughout, fig. 169A, posterior margin of apical portion of each style concave, fig. 169C.....9. **panda**
Aedeagus shaft more slender; posterior margin of apical portion of each style not concave.....17
17. Processes of aedeagus more than half as long as aedeagus shaft, as in figs. 161A, 170A.....18
Processes of aedeagus less than half as long as aedeagus shaft.....19
18. Apical portion of each style, fig. 161C, narrow, gradually tapered to a blunt apex; tooth on ventral margin not prominent.....1. **vincula**
Apical portion of each style, fig. 170, narrow, almost parallel margined, apex rounded; pointed prominent tooth on ventral margin about one-fourth the distance from the apex.....10. **tenella**
19. Aedeagus shaft, fig. 168, narrow, terminal processes convexly curved away from shaft; apical portion of each style, fig. 168, short, straight on posterior margin.....7. **flavilineata**
Aedeagus shaft, fig. 164, broad at base, narrowed toward apex, terminal processes more concavely curved and closer to shaft; apical portion of each style longer, slightly and convexly rounded posteriorly.....4. **ortha**
20. Aedeagus shaft, fig. 172, narrowed just before point of origin of terminal processes; apical portion of each style tapered to blunt apex.....12. **tubera**
Aedeagus shaft, fig. 173, not narrowed anterior to terminal processes; apical portion of each style narrowed to a sharper pointed apex.....13. **turbina**
21. Vertex about two-thirds as long at middle as basal width between the eyes.....7. **flavilineata**, 8. **conspira**, 9. **panda**, 12. **tubera**, 13. **turbina**, 15. **extenda**, 18. **octolineata**, 20. **angula**
Vertex shorter, about one-half as long at middle as basal width between the eyes.....2. **conferta**, 3. **brevihama**, 4. **ortha**, 5. **brevita**, 11. **amara**, 13. **turbina**, 16. **protenta**, 17. **scrupulosa**, 19. **serpenta**

1. *Gyponana vincula* DeLong

Gyponana vincula DeLong (1942, p. 47).

Length 8–10 mm. Resembling *octolineata* in form and general appearance, but male with distinctive genitalia. Vertex roundedly produced, not quite twice as wide as median length. Pale yellow, mottled with orange. Each male style, fig. 161C, with apical third slender, curved gradually dorsally and about uniform in width throughout except for a pointed tooth on ventral margin about one-fifth the distance from the blunt rounded apex. Aedeagus, fig. 161A, tapered toward apex with a pair of long slender apical processes arising just before apex and extending more than two-thirds the distance toward base of aedeagus body.

The species is distributed from Connecticut and Pennsylvania west to Utah and Texas.

Illinois Records.—CHAMPAIGN: Sept. 30, 1892, Snow, 1 ♀. LONG LAKE: 1 ♂. QUINCY: Aug. 8, 1889, Hart, 1 ♀. SPRINGFIELD: July 6, 1885, 1 ♂. URBANA: Sweep-ing in forest, June 27, 1889, Hart, 1 ♀; Sept. 3, 1890, Hart & Shiga, 1 ♀; Sept. 27, 1892, Snow, 1 ♀; Oct. 17, 1892, Snow & Marten, 1 ♀.

2. *Gyponana conferta* DeLong

Gyponana conferta DeLong (1942, p. 24).

Length 8.5–12.0 mm. Resembling *brevihama* but with vertex more broadly rounded and each style of male more narrowed on apical fifth. Vertex more than one-half as long at middle as width between eyes. Yellowish, with pruinose coloration on elytra. Male aedeagus, fig. 162, with a pair of short terminal processes that are directed basally and slightly laterally. Each style, fig. 162C, with a sharp pointed tooth produced on outer margin at about one-fifth the distance from apex; apical portion beyond tooth bent upward and gradually tapered to a rather bluntly rounded tip.

This species is known from only Illinois and Texas, but possibly is more widely distributed.

Illinois Records.—Many males and females, taken June 13 to November 12, are from Belvidere, Champaign, Eichorn, Elizabethtown, Golconda, Mahomet, Oakwood, Palos Park, Rock Island, St. Joseph, Seymour, Urbana, Western Springs, and Zion.

3. *Gyponana brevihama* DeLong

Gyponana brevihama DeLong (1942, p. 24).

Length 9.5 mm. Resembling *octolineata* in form and general appearance but male with distinctive genitalia. Vertex rather strongly and roundedly produced, about two-thirds as long as wide. Yellowish, with eight orange longitudinal lines on vertex, pronotum, and scutellum. Each male style, fig. 163C, with broad apical portion about twice as long as broad and slightly tapered to blunt rounded apex. Aedeagus, fig. 163A, with a pair of short slightly curved lateral processes that are directed basally; they are about one-fourth as long as the straight ventral portion of the aedeagus body beyond the curved base.

This species has been taken previously in Ohio, Pennsylvania, and Mississippi.

Illinois Record.—HAVANA: Devil's Rock, June 22, 1926, Frison & Hayes, 4 ♂.

4. *Gyponana ortha* DeLong

Gyponana ortha DeLong (1942, p. 25).

Length 9.5–10.5 mm. Resembling *octolineata* in form and appearance, but male with distinctive genitalia. Vertex strongly produced and appearing narrow, about two-thirds as wide as long. Yellowish; longitudinal lines on vertex and pronotum distinct, but rather faint. Each male style, fig. 164C, with apical third gradually curved dorsally; apical fourth abruptly bent and gradually narrowed to a bluntly curved apex. Aedeagus, fig. 164A, with a pair of rather short apical lateral processes that are about one-fourth the length of the ventral body of the aedeagus and are directed basally.

This species is widely distributed from Maryland west to Wisconsin and Kansas.

Illinois Records.—Males and females, taken June 5 to October 3, are from Clayton, Des Plaines, Fox Lake, Grantsburg, Hardin, Jacksonville, Quincy, Reynolds-ville, Springfield, Urbana, Villa Ridge, White Heath, and Wilmington.

5. *Gyponana brevita* DeLong

Gyponana brevita DeLong (1942, p. 27).

Length 9.5 mm. Resembling *octolineata* in form and appearance, with male genitalia distinctive. Vertex rather broadly rounded,

twice as wide as long. Yellowish, with pale irregular longitudinal stripes on the vertex, pronotum, and scutellum. Each male style, fig. 165C, gradually narrowed on apical sixth on ventral margin to a pointed apex. Aedeagus, fig. 165A, with a pair of lateral processes arising just before apex and extending laterally and then curved basally; processes about one-sixth the length of the ventral body of the aedeagus.

This species is known only from Illinois, Wisconsin, and Tennessee.

Illinois Records.—MACOMB: in pasture, July 3, 1934, DeLong & Ross, 1 ♂, 1 ♀ paratype. SAVANNA: July 19, 1892, Hart, Shiga, Forbes, & McElfresh, 1 ♂ paratype; July 27, 1892, Hart, Shiga, Forbes, & McElfresh, 1 ♂ paratype.

6. *Gyponana orientala* DeLong

Gyponana orientala DeLong (1942, p. 26).

Length 10 mm. Resembling *octolineata* in color and general appearance, but male with distinctive genital structures. Vertex rather short and broad, almost twice as wide as long. Pale yellow, faintly marked with longitudinal orange bands on vertex, pronotum, and scutellum. Each male style, fig. 166C, with apical sixth gradually narrowed on ventral margin to a bluntly pointed apex. Aedeagus, fig. 166, with a pair of short lateral processes that arise just before apex, extend laterally and then curve basally.

This species has been collected in a few localities in the eastern United States and in Texas.

Illinois Records.—GALENA: July 10, 1934, DeLong & Ross, 1 ♂. MONTICELLO: June 11, 1934, Frison & DeLong, 3 ♂. WHITE HEATH: July 5, 1916, 2 ♂.

7. *Gyponana flavilineata* (Fitch)

Gypona flavilineata Fitch (1851, p. 57).

Length 9.5–11.0 mm. Resembling *octolineata* in form and appearance. Vertex narrow, rather strongly produced and rounded, two-thirds as long as wide. Yellow; vertex, pronotum, and scutellum marked with orange-yellow longitudinal bands. Each male style, fig. 168C, with the apical third representing a foot with the bottom flat; heel abruptly bent on the ventral side, the dorsal margin curved and narrowed to the apex, which is curved to

outer margin. Aedeagus, fig. 168, narrowed to apex, where a pair of lateral curved processes extend laterally and then basally for more than one-fourth the distance to base.

This species ranges from Florida to Maryland and west to Utah and Texas.

Illinois Records.—Many males and females, taken June 5 to October 10, are from Albion, Apple River, Canyon State Park, Beardstown, Byron, Cairo, Champaign, Danville, Eichorn, Geff, Gulfport, Havana, Harrisburg, Herod, Homan, Kampsville, Kankakee, Le Roy, Lima, Mokence, Monticello, Mount Carmel, Moweaqua, Norris City, Olive Branch, Omaha, Shawneetown, Siegel, Springfield, Urbana, Vandalia, Vienna, and White Pines Forest State Park.

8. *Gyponana conspira* DeLong

Gyponana conspira DeLong (1942, p. 31).

Length 9.5–11.0 mm. Resembling *flavilineata* in general form and appearance, but with distinctive genitalia. Vertex roundedly produced, almost two-thirds as long at middle as basal width between the eyes. Pale yellowish; vertex, pronotum, and scutellum marked with longitudinal orange bands. Elytra yellowish subhyaline. Each male style, fig. 171C, slightly bent to form apical fourth, which is slightly widened on inner margin and then tapered to a bluntly rounded apex. Aedeagus, fig. 171, long, slender, with a pair of short lateral processes arising just before apex and extending basally one-fourth the length of the body of the aedeagus.

This species was described from Maine, Maryland, New York, and Illinois.

Illinois Record.—URBANA: June 30, 1891, Mitchell, 1 ♂.

9. *Gyponana panda* DeLong

Gyponana panda DeLong (1942, p. 32).

Length 9.5–10.0 mm. Resembling *flavilineata* in form and general appearance, but male with distinctive genitalia. Vertex narrow, strongly produced, rounded at apex, two-thirds as long as wide. Pale, marked with orange longitudinal bands on vertex, pronotum, and scutellum. Each male style, fig. 169C, with apical fifth bent abruptly dorsad, outer margin concavely curved to

form an almost parallel-margined narrow finger-like process, which is curved caudad and is bluntly rounded at apex. Aedeagus, fig. 169, rather short and broad, with a pair of short appressed lateral processes arising just before apex and extending basally about one-third the length of the body of the aedeagus.

A widely distributed species in the Middle West and South, *panda* is also found in Oregon.

Illinois Records.—Many males and females, taken June 12 to November 15, are from Alton, Cobden, Dolson, Grand Tower, Havana, Homer, Kirkwood, Normal, Norris City, Oakwood, Oregon, Pike, Princeton, Quincy, Ripley, Savanna, Shawneetown, Sherman, Temple Hill, Urbana, and Watson.

10. *Gyponana tenella* (Spangberg)

Gypona tenella Spangberg (1878*b*, p. 34).

Length 7–8 mm. Small, with a broadly rounded vertex. Vertex short, twice as wide as median length. General color pale green; vertex, pronotum, and scutellum marked with orange longitudinal bands. Veins of elytra inconspicuous. Each male style, fig. 170, narrowed on apical third, then curved dorsally with a pointed tooth on ventral margin about one-fourth the distance from the apex; gradually narrowed from this tooth to form a rather long narrow process, which is blunt and rounded at apex. Aedeagus rather narrow, with a pair of lateral processes arising just before apex; processes curved laterally and extended basally almost to base of ventral body of aedeagus.

This species has been previously recorded from the southeastern states only.

Illinois Record.—GRAND TOWER: July 12, 1909, 1 ♂.

11. *Gyponana amara* DeLong

Gyponana amara DeLong (1942, p. 32).

Length 9.0–9.5 mm. Resembling *octolinata* in general appearance but with more produced vertex and with distinctive male genitalia. Vertex strongly and rather angularly produced, with apex rounded; more than half as long at middle as basal width between eyes. Pale yellow, conspicuously marked with bright orange longitudinal stripes on vertex, pronotum, and scutellum.

Elytra pale with darker veins. Each male style, fig. 167, with outer margin curved slightly outwardly on apical portion, tip curved caudadly, angularly widened on inner margin about one-sixth the distance from apex and then tapered to upturned blunt tip. Aedeagus narrowed toward apex, with a pair of rather short lateral processes arising just before apex and extending basally about one-third the length of body of aedeagus.

This species was described from Illinois, Missouri, and Ohio.

Illinois Records.—ANTIOCH: Aug. 24, 1935, DeLong & Ross, 2 ♂, 2 ♀ paratypes. ATLAS: July 28, 1936, Mohr & Burks, 1 ♀ paratype. CHICAGO: Aug. 21–24, 1901, Titus, 1 ♂. HEROD: June 24, 1936, DeLong & Ross, 1 ♀ paratype. MUNCIE: cattail bog, Sept. 10, 1936, Burks, 1 ♂ paratype. SHAWNEETOWN: June 27, 1936, DeLong & Mohr, 3 ♂, 9 ♀ paratypes. SPRINGFIELD: July 2, 1885, 1 ♂. URBANA: Oct. 11, 1938, Riegel, 1 ♂ paratype.

12. *Gyponana tubera* DeLong

Gyponana tubera DeLong (1942, p. 33).

Length 9.5–10.5 mm. Resembling *flavilineata* in form and general appearance but with distinctive genitalia. Vertex roundedly produced, less than two-thirds as long at middle as width between the eyes. Pale yellow, marked with faint orange longitudinal bands on vertex, pronotum, and scutellum. Each male style, fig. 172, bent dorsally and caudad, and narrowed at one-fifth the distance from apex, gradually narrowed to rounded blunt apex. Aedeagus with a pair of lateral processes arising just before bluntly pointed apex, curved laterally and basally about one-third the distance to base; aedeagus body is constricted just basad to point of origin of the apical lateral processes.

This species is found in the eastern United States and is distributed west to Tennessee and South Dakota. In Illinois it is known from only the southern half.

Illinois Records.—DANVILLE: July 30, 1917, 1 ♂ paratype. HEROD: Aug. 4, 1934, DeLong & Mohr, 1 ♀; July 8–11, 1935, DeLong & Ross, 1 ♂; June 20, 1938, DeLong & Ross, 1 ♀. MAKANDA: Aug. 20, 1891, French, 1 ♂. ROSICLARE: July 5, 1935, Frison & Mohr, 1 ♂.

13. *Gyponana turbina* DeLong

Gyponana turbina DeLong (1942, p. 37).

Length 9.5–11.0 mm. Resembling *flavilineata* in form and appearance but with distinctive male genitalia. Vertex broadly rounded, produced at middle, almost twice as wide as long. Green, vertex mottled with orange yellow. Each male style, fig. 173, curved slightly dorsad, with a broad short tooth on ventral margin about one-sixth the distance from the apex, the style gradually narrowed from this tooth to a pointed apex. Aedeagus narrowed apically, with a pair of lateral processes arising just before apex; processes curving basally and extending along body of aedeagus one-third the distance to the base.

This species is widely distributed from the East Coast west to Texas and Utah.

Illinois Records.—Males and females, taken May 23 to September 20, are from Champaign, Cornfield, Dixon Springs, Fulton, Herod, Meredosia, Muncie, Sugar Grove, Urbana, Volo, and White Pines Forest State Park.

14. *Gyponana expanda* DeLong

Gyponana expanda DeLong (1942, p. 38).

Length 10.5 mm. Resembling *octolineata* in form and appearance but with head more produced and with distinctive male genitalia. Vertex produced and rather broadly rounded, almost two-thirds as long as basal width between the eyes; margin thin and slightly curved upwards. Pale, almost white, with orange longitudinal bands on vertex, pronotum, and scutellum. Elytra with green veins. Each male style, fig. 154, curved dorsally on apical sixth, where a short pointed tooth arises on ventral margin; beyond this the apical portion is gradually tapered to a bluntly pointed apex. Aedeagus constricted at middle, decidedly enlarged and broadly rounded at apex; a pair of lateral processes arising at apex, curving laterally, and then extending basally about one-third the distance to the base of aedeagus body.

This species is known only from Illinois, Missouri, and Ohio.

Illinois Records.—DIXON SPRINGS: June 24, 1936, DeLong & Ross, 1 ♂, 5 ♀ paratypes. HOMER PARK: July 19, 1924, Frison, 2 ♂ paratypes; at light, July 11, 1927, Frison & Glasgow, 1 ♀ paratype.

15. *Gyponana extenda* DeLong

Gyponana extenda DeLong (1942, p. 39).

Length 10–12 mm. Resembling *flavilineata* in form and general appearance but with distinctive male genitalia. Vertex strongly produced, apex rounded, almost three-fourths as long as wide. Pale yellow, marked with faint longitudinal orange bands on vertex, pronotum, and scutellum. Each male style, fig. 155, strongly curved dorsally on apical third, and bearing a short tooth on the ventral margin about one-sixth the distance from apex; beyond tooth, style narrow and almost parallel margined to blunt apex. Aedeagus constricted near middle and enlarged at apex; a pair of lateral processes arising a short distance before produced rounded apex, extending laterally, and then curving basally to a point about one-third the distance to the base.

This species is widely distributed over the eastern United States.

Illinois Records.—APPLE RIVER CANYON STATE PARK: July 11, 1934, DeLong & Ross, 1 ♂, 3 ♀ paratypes. DOLSON: Rocky Branch, July 18, 1934, DeLong & Ross, 1 ♂, 2 ♀ paratypes. LA GRANGE: Aug. 23, 1935, DeLong & Ross, 2 ♂, 1 ♀ paratypes. OAKWOOD: Aug. 17, 1934, DeLong & Ross, 1 ♂ paratype. THEBES: July 29, 1909, 1 ♂ paratype; on cane, July 11, 1935, DeLong & Ross, 1 ♂ paratype.

16. *Gyponana protenta* DeLong

Gyponana protenta DeLong (1942, p. 41).

Length 9.5 mm. In general appearance resembling *acia* DeLong, but with vertex more strongly produced and with style long and narrow. Vertex roundedly produced, more than half as long at middle as basal width between eyes. Pronotum a little longer than vertex. Yellowish, vertex and pronotum with longitudinal orange bands. Elytra subhyaline, tinged with orange. Each style, fig. 156, with apical half gradually tapered to narrow rounded apex; outer margin angled one-fifth the distance from apex and bent upward; apical fifth narrow and fingerlike. Aedeagus with a pair of lateral terminal processes that extend laterally for a short distance, then curve and extend basally almost half the distance to base; they are tapered to fine pointed tips.

This species is known from Illinois and Ohio only.

Illinois Records.—GRAFTON: along river, June 26, 1934, DeLong & Ross, 1 ♂, 2 ♀. JUSTICE: July 23, 1937, Mohr & Burks, 1 ♂ paratype. MARSHALL: Sept. 27, 1934, 3 ♀. URBANA: June 21, 1936, Burks, 1 ♀ paratype; June 24–25, 1936, Riegel, 2 ♂ paratypes; Sept. 8, 1938, Riegel, 1 ♂ paratype; Sept. 10, 1938, Riegel 1 ♂ paratype; Sept. 14, 1938, Riegel, 1 ♂ paratype. WHITE PINES FOREST STATE PARK: Aug. 13–14, 1937, Ross & Burks, 1 ♂ paratype.

17. *Gyponana scrupulosa* (Spangberg)

Gypona scrupulosa Spangberg (1878*b*, p. 9).

Length 9.0–9.75 mm. Yellowish, closely related to *octolineata*. Vertex rather short and broadly rounded; almost twice as wide as long, without definite markings. Each male style, fig. 157, with apical third rather broad to ventral tooth on basal portion; beyond this the apical one-sixth of style is narrow, produced dorsally, and curved anteriorly to a bluntly pointed apex. Aedeagus with a pair of short lateral processes arising just before apex and recurved inwardly.

This is a widely distributed and common eastern species ranging west to Wisconsin and Texas.

Illinois Records.—Males and females, taken June 20 to October 3, are from Algonquin, Alto Pass, Anna, Anvil Rock, Bluffs, Borton, Cave in Rock, Champaign, Clay City, Dubois, Du Quoin, East St. Louis, Elizabeth, Elizabethtown, Mason City, Metropolis, Normal, Pulaski, Putnam, Urbana, Warren, and Waukegan.

18. *Gyponana octolineata* (Say)

Tettigonia octolineata Say (1825, p. 340).
Gypona geminata Osborn (1905*b*, p. 513).

Length 9–10 mm. Greenish to pale yellow, with eight reddish longitudinal lines on vertex and pronotum. Vertex produced and broadly rounded, about two-thirds as long at middle as basal width between eyes. Each male style, fig. 159, with apical one-sixth gradually narrowed from ventral tooth to a blunt apex; the caudal margin is straight and the apical portion does not curve anteriorly. Aedeagus with a pair of short lateral processes that arise just before apex and extend laterally, their apices recurved.

This species occurs in the eastern United States.

Illinois Records.—PHILLIPSTOWN: June 24, 1936, DeLong & Ross, 2 ♂. URBANA: June 21, 1936, B. D. Burks, 1 ♂; light trap, Sept. 5–9, 1938, G. T. Riegel, 3 ♂, 2 ♀.

19. *Gyponana octolineata* var. *serpenta* DeLong

Gyponana octolineata var. *serpenta* DeLong (1942, p. 53).

Length 9–11 mm. Similar to *octolineata* in form and appearance but each style with a slightly curved apical portion. Vertex strongly produced, broadly rounded, a little more than half as long at middle as basal width between eyes. Pale yellow, vertex, pronotum, and scutellum marked with longitudinal orange bands. Each male style, fig. 160, with apical sixth gradually constricted to blunt apex and slightly curved anteriorly. Aedeagus rather broad, with a pair of short lateral processes that are curved strongly on apical portions.

A widely distributed and common variety in the eastern states, *serpenta* ranges west to Wyoming.

Illinois Records.—Males and females, taken June 11 to October 13, are from Alto Pass, Anna, Carbondale, Cave in Rock, Dongola, Dubois, Gibsonia, Kampsville, Long Lake, Oquawka, St. Anne, Sparta, Springfield, Urbana, Volo, Waukegan, and Woodworth.

20. *Gyponana angula* DeLong

Gyponana angula DeLong (1942, p. 54).

Length 9–10 mm. Resembling *octolineata* in form and general appearance, male genitalia distinctive. Vertex roundly produced, about two-thirds as long as wide. Yellowish, mottled with orange on vertex, pronotum, and scutellum, longitudinal bands usually distinct. Elytra often tinged with orange, veins pale green. Each male style, fig. 158, with apical sixth narrowed beyond ventral pointed tooth to form a narrow constricted portion just before a slightly enlarged rounded blunt apex. Aedeagus with a pair of short basally directed and apically curved processes.

This species is found in the eastern states and west as far as Texas. It is very rare in Illinois.

Illinois Records.—METROPOLIS: Aug. 19, 1916, 1 ♂ paratype. OMAHA: June 23, 1936, DeLong & Ross, 2 ♂.

26. *RUGOSANA* DeLong

Rugosana DeLong (1942, p. 64).

Related to and similar to *Gyponana* but with elytra rugose or roughened. Usually the vertex and pronotum are rugose also. The members of this genus may be distinguished from those of genera having a strong venation, in which the veins appear embossed. The rugose character in this genus is not caused by the condition of the veins, but by the venation of irregular reticulation which may tend to cause it to be more conspicuous. The vertex is flattened, depressed, and is strongly foliaceous. The pronotum bears a large round black spot about the middle behind each eye. The elytra are often so colored as to appear with many crossveins; apical portion has numerous crossveins.

This is a small genus of nine species, which are found chiefly in the Southwest, but the genus contains one widespread species that has been taken in Illinois.

1. *Rugosana querci* DeLong

Rugosana querci DeLong (1942, p. 69).

Fig. 153. Length 9–10 mm. Resembling *rugosa* (Spangberg) (1878*b*, p. 6), but with distinctive genitalia. Vertex produced and rather broadly rounded, almost twice as wide as long. Pale yellow, with traces of longitudinal orange bands on vertex, pronotum, and scutellum. Pronotum with a conspicuous round black spot on each side of outer margin of disc. Elytra pale, mottled with brownish yellow, causing a rugose appearance.

Female seventh sternite, fig. 153, almost truncate on posterior margin, median third abruptly excavated one-half the distance to the base, the excavation bearing a broad blunt rounded tooth slightly notched at middle and produced about one-third the depth of the excavation. Each male style, fig. 153, with basal third narrow and constricted at two-thirds its length, thus forming two convexly rounded ventral lobes, the apical one of which is serrate and extends to the broad bluntly rounded apex. Aedeagus, fig. 153, with an abruptly narrowed, prolonged, finger-like apical process at the base of which on either side arises a long slender process; each process crosses the one from the opposite side and extends apically the length of the body of the aedeagus.

A widely distributed eastern species, *querci* occurs as far west as Utah and Arizona. It is a common species on oak in the eastern and southern states.

Illinois Records:—ALCONQUIN: Aug. 25, 1897, 1 ♀ paratype. ASHLEY: Aug. 7, 1871, 1 ♀ paratype. DOLSON: Rocky Branch, July 18, 1934, DeLong & Ross; 1 ♀ paratype. DUBOIS: Aug. 8, 1917, 2 ♂, 5 ♀ paratypes. HAVANA: Aug. 20, 1917, 1 ♀ paratype. MEREDOSIA: Aug. 19, 1917, 5 ♂, 11 ♀ paratypes. SAVANNA: July 27, 1892, McElfresh, Shiga, Forbes, & Hart, 1 ♀ paratype.

27. *PRAIRIANA* Ball

Prairiana Ball (1920, p. 90).

Related to and similar to *Rugosana*, but with eyes small and widely separated. Usually decidedly flattened and some shade of brown or black. Pronotum broad, flat, lateral margins almost straight. Vertex about as wide as pronotum, often elongate, and with thin foliaceous anterior margin. Elytra often shorter than abdomen. Ocelli on disc usually a little nearer median line than eyes.

Fifteen species and several varieties have been recorded for the United States. Two species and one variety are known to occur in Illinois.

KEY TO SPECIES

Length more than 8 mm.; vertex broadly and angularly produced, apex rounded, more than two-thirds as long at middle as basal width between eyes.....2. *kansana*
Length about 7 mm.; vertex more broadly rounded, slightly more than half as long as wide.....1. *cinerea*

1. *Prairiana cinerea* (Uhler)

Gypona cinerea Uhler (1877, p. 460).

Length 7–9 mm. Small, with a broadly rounded head. Vertex broadly rounded and produced, about one-third wider than long. Pale brown, with dark brown punctures. Vertex with a black spot each side on base of vertex half way between eye and median line. A spot on anterior portion of pronotum behind each spot on vertex. Veins of elytra margined with dark brown punctures and with scattered brownish spots. Female seventh sternite concavely rounded on posterior margin either side of a slightly produced median rounded lobe. Each male style gradually tapered on apical half to a

rather blunt slightly broadened apex. Aedeagus with dorsal portion deeply and concavely excavated on dorsal surface just before apex, which is produced to form long, dorsally curved, pointed processes; ventral portion curved back upon itself so that the apex is in the concavity of the dorsal portion.

This is a widespread middle western species found as far west as Colorado and Montana.

Illinois Record.—CHICAGO: (Glenview), June 5, 1912, 1 ♂.

2. *Prairiana kansana* Ball

Prairiana cinerea var. *kansana* Ball (1920, p. 91).

Length 9 mm. Broad, with a broad almost angularly produced vertex. Vertex about two-thirds as long at middle as basal width between eyes. Pale brown, vertex and pronotum heavily marked with brownish punctures. Veins of elytra faintly marked with brown. Female seventh sternite with produced lateral angles, between which the posterior margin is concavely excavated on either side of a median lobe; lobe rounded, produced, and slightly notched at apex. Male style similar to that of *cinerea*, concavely rounded, narrowed just before blunt apex, which is slightly enlarged. Aedeagus shallowly and concavely excavated just before dorsally curved sharply pointed apex, which extends dorsad.

This species, and its variety *angustens*, have been taken in the Middle West only.

Illinois Record.—HANOVER: sand prairie, July 10, 1934, DeLong & Ross, 1 ♂.

Prairiana kansana var. *angustens* DeLong

Prairiana kansana var. *angustens* DeLong (1942, p. 83).

Length 10.5 mm. Resembling *kansana* in general appearance, but more slender, elongate, and with vertex more pointed. Vertex about one-third wider between eyes than median length. Pale brown, tinged with white. Vertex and pronotum punctate with small brown spots. Elytra pale, faintly margined with brown. The male aedeagus and styles are similar to those of *kansana*.

Illinois Records.—EVERGREEN PARK: July 1, 1935, 1 specimen. URBANA: July 21, 1936, B. D. Burks, 4 ♂; July 25, 1934, Frierson & DeLong, 1 ♂.

28. *PONANA* Ball

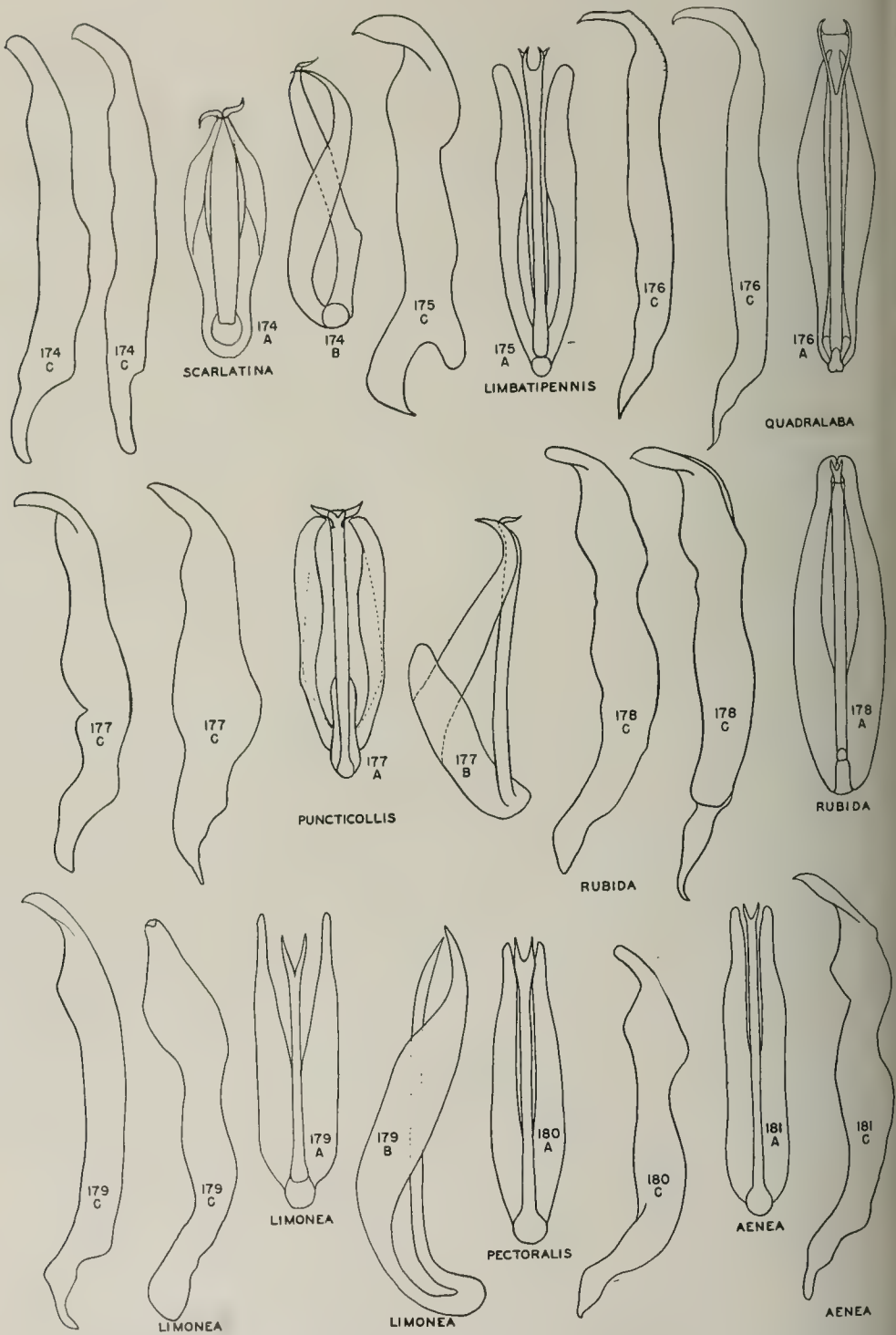
Ponana Ball (1920, p. 93).

Fig. 22. Related to and similar to *Gypsona*, but with body more convex and cylindrical in type. Pronotum conspicuously wider than vertex, transverse, striated, convexly sloping to vertex; lateral margins almost angled, laterally produced. Vertex usually convex or sloping, with a rather definite depression just before the thickened anterior margin, depression also indicated below margin; vertex and front meeting at nearly a right angle, front scarcely inflated. Ocelli rather large, on disc before middle.

The genus contains 22 species in the Nearctic region distributed over the eastern United States and the Southwest. Four of these species have been taken in Illinois, while several others may occur here.

KEY TO SPECIES

- 1. Vertex and often pronotum marked with small reddish dots.....2
Vertex and pronotum without reddish dots.....3
- 2. Vertex produced at middle; pronotum with two black spots on anterior margin, one behind each ocellus. **1. scarlatina**
Vertex more broadly rounded; pronotum with four black spots on anterior margin, one behind each ocellus and one behind each eye.....**2. puncticollis**
- 3. Pronotum and elytra heavily punctate with small brown spots.....**2. puncticollis**
Pronotum and elytra not marked with small brown spots.....4
- 4. Elytra uniformly dark brown to black, costae conspicuously yellow; vertex and pronotum pale, unmarked.....**5. limbatipennis**
Elytra not uniformly dark in color.....5
- 5. Anterior portion of pronotum with four conspicuous spots.....**7. quadralaba**
Pronotum without definite dark markings on anterior portion.....6
- 6. Dull yellowish green, scutellum and claval area smoky to dark brown.....7
Claval area not smoky or brown, elytra usually with spots or crossveins pigmented.....8
- 7. Elytra smoky along commissural line; male styles, fig. 179C, shallowly excavated on inner margins; central portion of aedeagus, fig. 179A, more deeply and angularly excavated at apex.....**8. limonea**
Elytra heavily and broadly marked with brown along commissure; male styles, fig. 180C, more deeply and roundedly excavated on inner margins; apex of central portion of aedeagus, fig. 180A, rather deeply and roundedly excavated.....**6. pectoralis**



Figs. 174-181.—*Ponana*, male genitalia. A, ventral aspect of aedeagus; B, lateral aspect of aedeagus; C, style, two views.

8. Male styles, fig. 178C, shallowly and roundedly notched on outer margins; central portion of aedeagus, fig. 178A, straight and bifurcate at apex; elytra with dark brown pigment markings, resembling crossveins, especially on clavus just posterior to scutellum. . . . 4. *rubida*
Male styles, fig. 181C, deeply and angularly notched on outer margins; central portion of aedeagus, fig. 181A, constricted just before bifurcate apical portion; elytra pale to dark brown

3. *aenea*

1. *Ponana scarlatina* (Fitch)

Gypona scarlatina Fitch (1851, p. 57).
Gypona irrorella Spangberg (1878b, p. 60).
Gypona spadix DeLong (1918b, p. 235).
Gypona rodora Ball (1920, p. 96).

Length 8.5–9.0 mm. Yellowish brown, completely dotted with bright red in well-marked specimens. Head narrow, vertex broadly rounded, almost twice as wide as long. Varying from buff to brown, and usually marked with red spots on all portions of dorsal surface. Veins frequently red. The degree and intensity of coloration is quite variable.

Female seventh sternite with well-produced rounded lateral angles, between which the posterior margin is concavely excavated either side of a broad median produced lobe, which is slightly notched at middle. Each male style, fig. 174, with apical portion narrowed but almost parallel margined to apex, which is rather broad and rounded and with a short point on inner apex. Aedeagus in ventral view, fig. 174, with a pair of forceps-like structures and a median elongated portion, which bears a pair of small curved lateral processes at the apex.

A widely distributed eastern species, *scarlatina* ranges west to Kansas and Texas.

Illinois Records.—OLIVE BRANCH: Horseshoe Lake, Aug. 2, 1934, DeLong & Mohr, 1 ♂. VIENNA: July 29, 1934, DeLong & Ross, 1 ♀.

2. *Ponana puncticollis* (Spangberg)

Gypona puncticollis Spangberg (1878b, p. 54).
Gypona sanguinolenta Spangberg (1878b, p. 63).
Gypona grisea Spangberg (1878b, p. 64).
Gypona proscripta Fowler (1903, p. 309).

Length 9 mm. Pale brownish, with four large round spots just behind anterior margin of pronotum and with elytra heavily marked with brownish irrorations. Vertex

rather strongly produced and rounded, more than half as long at middle as basal width between the eyes. Vertex and pronotum often with fine brown or reddish punctures. Elytra generally marked with small round brownish spots; in addition there are heavy brownish areas arranged in two broken transverse bands across each clavus. The intensity of these bands varies.

Female seventh sternite with produced rounded lateral angles, between which the posterior margin is concavely excavated either side of a broad median lobe, which is produced beyond the lateral angles and slightly notched at middle. Each male style, fig. 177, broad, narrowed toward apex, and constricted to form a thick finger-like curved tip, which is bluntly pointed at apex. Aedeagus appearing in ventral view with the paired lateral processes blunt at apexes and rounded; median process long and slender, with broadened apex from which arise two lateral processes that are rigidly fastened together and form a semicircular band with sharp-pointed apexes curved ventrally.

This species has been recorded from Florida.

3. *Ponana aenea* DeLong

Ponana aenea DeLong (1942, p. 94).

Length 8 mm. Resembling *scarlatina* in general appearance, but with more markedly produced vertex and with distinctive male genitalia. Vertex rather strongly produced, apex rounded, more than half as long at middle as basal width between eyes. Yellow, tinged with brown. Elytra pale to dark brownish (sometimes with reddish flecks as in *scarlatina*).

Female seventh sternite with lateral angles produced and rounded, between which the posterior margin is concavely excavated either side of a pair of short broadly rounded median lobes separated by a short median notch. Each male style, fig. 181, broad, rather deeply and concavely notched on ventral margin at about the middle, angularly notched on dorsal margin a little farther apically, then decidedly narrowed and produced, forming a thick finger-like process directed outwardly and pointed at apex. Aedeagus as viewed ventrally with the paired lateral processes tapered at apexes; median slender portion bifid at apex, with very short apical processes.

The style and aedeagus are both excellent characters to separate this species from *scarlatina*.

This species has not been taken in Illinois, but is known to occur in Kansas and Missouri and east to Pennsylvania and Maryland.

4. *Ponana rubida* DeLong

Ponana rubida DeLong (1942, p. 95).

Length 9.0–9.5 mm. Resembling *scarlatina* in general appearance, but with brown ramose markings on elytra and with distinctive male genitalia. Vertex broadly rounded, a little more than half as long at middle as basal width between eyes. Dark brown pigment markings of elytra resembling crossveins; these more abundant on claval areas just back of apex of scutellum. Female seventh sternite roundedly produced, shallowly and broadly notched at apex, slightly sinuate on either side about half way between lateral angles and apex. Each male style, fig. 178, even broader than in *avena*, not so deeply notched on either ventral or dorsal edges and with apex shorter, thicker, and more blunt at apex than in that species. Aedeagus with the median process narrow, constricted on dorsal side, then bifurcate and broadened; ventral portion forming a sheath that is not constricted.

This is chiefly a middle western species, but has been taken as far east as Pennsylvania.

Illinois Records.—Males and females, taken June 2 to August 23, are from Apple River Canyon State Park, Dolson, Fox Lake, Havana, La Grange, northern Illinois, Oakwood, Savanna, Urbana, and Vienna.

5. *Ponana limbatipennis* (Spangberg)

Gypona limbatipennis Spangberg (1878*b*, p. 47).

Length 8.75–9.5 mm. Dark, with pale costal margins. Vertex broadly rounded, more than half as long as basal width between eyes. Color brownish yellow, vertex and pronotum usually unmarked, scutellum smoky, elytra usually smoky to black, apical half of each often paler with dark veins, costa with broad yellowish margin. Female seventh sternite with posterior margin slightly sinuate; broadly and shallowly notched at middle. Each male style, fig. 175,

rather slender, rather shallowly notched on ventral and dorsal margins, abruptly narrowed just before apex, the apical tip rather slender; finger-like apex curved to a point on inner margin. Aedeagus with the paired lateral portions narrowed just before apex, with apices blunt, divergent; median process slender, slightly enlarged at apex, median portion excavated, with a slight median tooth at base; each arm forming the excavation bifid at apex, the outer tooth shorter than the inner tooth. The characters of the aedeagus will easily separate this from all allied species.

This is a middle western species recorded from Ohio, Illinois, and Iowa.

Illinois Records.—ALCONQUIN: July 8, 1897, 1 ♀. APPLE RIVER CANYON STATE PARK: July 11, 1934, Ross & DeLong, 1 ♂, 1 ♀. MARSHALL: June 14, 1933, Frison & Ross, 1 ♂. OAKWOOD: June 14, 1935, Mohr, 1 ♂. STARVED ROCK STATE PARK: June 28, 1937, Ross & Burks, 1 ♂. STRATFORD: June 22, 1917, 1 ♂. URBANA: June 17, 1889, Hart, 1 ♂.

6. *Ponana pectoralis* (Spangberg)

Gypona pectoralis Spangberg (1878*b*, p. 46). *Gypona albimarginata* Woodworth (1887, p. 31).

Gypona bimaculata Woodworth (1887, p. 32). *Gypona woodworthii* Van Duzee (1915*b*, p. 569).

Length 10 mm. Yellowish brown, with dark coloration on the corium and clavus of each elytron. Vertex broadly produced, more than half as long as basal width between the eyes. Disc of pronotum darker than elytra; scutellum darker on anterior half; elytra yellowish, subhyaline claval area more smoky and with brownish spots on each corium and clavus.

Female seventh sternite with posterior margin broadly and rather shallowly notched at middle, with a rounded lobe either side, the lobe usually slightly sinuate at middle. Each male style, fig. 180, broad, deeply and concavely notched on inner margin, then enlarged and sloped to a rather thick finger-like apex, which is formed by a deep angular notch on inner margin. Aedeagus with apices of lateral paired portions blunt and divergent, median portion slender, enlarged at apex, rather deeply notched, forming a pair of divergent pointed tips.

This species is distributed from the Dis-

trict of Columbia west to Kansas and Texas.

Illinois Records.—Many males and females, collected May 26 to August 22, are from Antioch, Dolson, Fox Lake, Galena, Grand Tower, Homan, Kampsville, Kankakee, La Grange, Mount Carmel, Oak Lawn, Oquawka, Pulaski, Savanna, Thebes, Vienna, Urbana, and White Heath.

7. *Ponana quadralaba* DeLong

Ponana quadralaba DeLong (1942, p. 98).

Length 7.0–8.5 mm. Small, yellowish to brownish, with four black spots on anterior portion of pronotum. Vertex broadly rounded, more than half as long at middle as basal width between eyes. Each elytron with a few brown blotches on clavus and apex of clavus, and one on corium.

Female seventh sternite concavely rounded from lateral angles to the slightly produced median third, which is broadly and shallowly notched at middle, forming a part of the proximal rounded lobes. Each male style, fig. 176, rather narrow, sides scarcely sinuate to a point near apex, where it is concavely excavated on inner margin, with apex strongly curved dorsally and produced into a finger-like process; style usually with a slightly enlarged blunt tooth on outer margin of curved portion at base of the finger-like process. Aedeagus with the paired lateral portions enlarged at middle, tapered to blunt apices; median process long, rather slender, decidedly broadened at apex, appearing deeply and angularly excavated, and forming two long divergent slender pointed processes; between processes is a membranous wall extending to one-fourth the distance from the pointed apices.

This species is distributed from New Jersey to Arizona.

Illinois Records.—Males and females, taken June 18 to October 2, are from Alton, Bluffs, Carbondale, Dubois, Elizabethtown, Gibsonia, Grafton, Omaha, Savanna, Shawneetown, Starved Rock State Park, Urbana, and Warren.

8. *Ponana limonea* Ball & Reeves

Ponana scarlatina var. *limonea* Ball & Reeves (1927, p. 498).

Length 10 mm. Smoky greenish, with a well-produced vertex. Vertex more than

half as long at middle as width between eyes. Vertex and pronotum often brighter green than elytra. Female seventh sternite almost truncate, with a broad shallow median notch at middle. Each male style, fig. 179, rather broad, with a produced rounded lobe on dorsal margin not far from apex; margin concavely rounded from rounded lobe to form a narrow produced apical process, which is pointed at tip. Aedeagus with lateral paired portions tapered to bluntly pointed apices; median process long, slender, enlarged at apex, with a pair of long slender tapered pointed processes separated by a deep V-shaped excavation.

This species is known from Ohio only.

Subfamily LEDRINAE

The members of this subfamily are easily recognized by a combination of characters. The forewings are deeply pitted, and the anterior part of the body is dorsoventrally flattened so as to appear wedge shaped. The elytra are laterally appressed at their apices, and together appear wedge shaped.

Lawson (1931a) records 13 species in the only genus, *Xerophloea*, belonging to this subfamily in the United States.

29. *XEROPHLOEA* Germar

Xerophloea Germar (1839, p. 190).

Mesodicus Fieber (1866, p. 501).

Parapholis Uhler (1877, p. 461).

Fig. 21. Head broad, vertex broadly angled or broadly rounded in front, flat, anterior margin thin. Elytra long, angularly pointed, perpendicular at apices. The entire dorsal surface, especially the pronotum and elytra, coarsely and rather densely pitted. The broad head and pronotum and the perpendicular character of elytra at the apices give to the insect a characteristic wedge-shaped appearance.

Four species of the genus are known to occur in the eastern United States. Two of these have been collected in Illinois.

KEY TO SPECIES

Vertex distinctly angulate, slightly over half as long at middle as width between eyes at base. Length 6.0–7.5 mm. **1. *viridis***
Vertex broadly rounded, at least two-thirds as long at middle as basal width between eyes. Length 7.5–8.0 mm. **2. *major***

1. *Xerophloea viridis* (Fabricius)

Cercopis viridis Fabricius (1794, p. 50).
Xerophloea grisea Germar (1839, p. 190).
Xerophloea virescens Stål (1854, p. 253).
Parapholis peltata Uhler (1877, p. 461).

Length 6.0–7.5 mm. Color green to brownish yellow. Head a little narrower than pronotum. Vertex convexly rounded on sides to a definitely angulate apex; little more than half as long at middle as basal width between eyes. Females usually light green, often marked with minute black dots, particularly along elytral veins. Males often appearing entirely brown, usually yellowish green, with the median line of vertex and posterior portion of pronotum brown.

A common species on upland meadows and prairies, *viridis* usually occurs on short grasses in association with *Aristida gracilis*. It is widely distributed throughout the United States.

Illinois Record.—OQUAWKA: on muskmelon, July 16, 1937, Mohr & Burks, 1 ♀.

2. *Xerophloea major* Baker

Xerophloea major Baker (1898c, p. 285).

Fig. 182. Length 7.5–8.0 mm. Large, stout, green, often well marked with numerous black dots. Head slightly narrower than pronotum. Vertex strongly and broadly rounded, two-thirds as long as width between eyes.

This species is unique in its large size and rounded vertex. It occurs in grasses

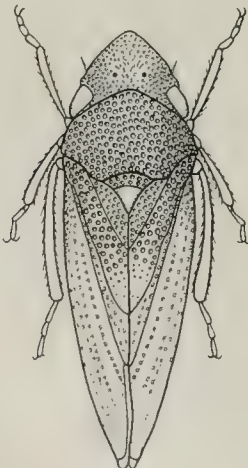


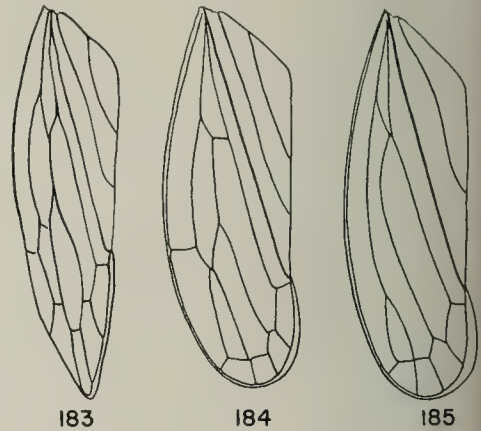
Fig. 182.—*Xerophloea major* ♀.

and is frequently found in the wet prairie. It ranges from the East Coast west to Tennessee and Kansas.

Illinois Records.—Males and females, taken June 27 to October 3, are from Albion, Alton, Anvil Rock, Barry, Cave in Rock, Kampsville, Oquawka, Port Byron, and Urbana.

Subfamily DORYDIINAE

All the genera of this group, especially in the female, have a produced flattened vertex with a sharp thin foliaceous margin. The ocelli are on the front margin and usu-



Elytra of Dorydiinae

Fig. 183.—*Dorydiella kansana*.

Fig. 184.—*Parabolocratus flavidus*.

Fig. 185.—*Spangbergiella quadripunctata*.

ally very close to the eyes. The females of most of the genera have the elytra short, exposing the last one or more abdominal segments.

This subfamily is represented by seven genera in the eastern United States, and five of these occur in Illinois.

KEY TO GENERA

1. Elytra narrowed posteriorly to pointed tips, fig. 183; general color brownish... 35. *Dorydiella*
 Elytra not narrowed posteriorly, apexes well rounded 2
2. Vertex with a broad deep longitudinal furrow, extending nearly to base of head, and a slight ridge on either side; pronotum with a sharp median carina, fig. 187 31. *Neoslossonia*
 Vertex flat, or with a median carina 3
3. Vertex extremely long and foliaceous, more than twice as long as basal width

between eyes, and with a median longitudinal carina extending nearly its full length, fig. 189; color brownish.....

30. Dorycephalus

Vertex usually more thickened, flat without carina, and not more than twice as long as basal width between eyes; color usually greenish, sometimes marked with black, red, or orange.....4

4. Elytra with one claval (anal) vein marked with red, fig. 185; head and pronotum with a pair of diagonal red or orange stripes.....**33. Spangbergiella**

Elytra with two claval veins, or veins obscured; stripes, if present, longitudinal.....5

5. Vertex decidedly longer than basa width between eyes.....6

Vertex not more than width between eyes, fig. 186B; color usually uniformly pale green.....**34. Parabolocratrus**

6. Body above pale green, with a pair of reddish stripes extending from front margin of vertex to posterior margin of scutellum, fig. 190; at least veins in basal half of elytra marked with red, orange, or yellow.....**32. Hecalus**

Body above straw colored, marked with brown; vertex with a broad, brown, irregular longitudinal band, fig. 188.....

36. Dicyphonia

30. DORYCEPHALUS Kuschakewitch

Dorycephalus Kuschakewitch (1866, p. 102).

Large, elongate, with extremely long produced flat head, which is thin and foliaceous on outer margin and at apex. Female with short elytra, exposing the last three to five dorsal segments of the abdomen; in the male the elytra usually extend to the apex of the abdomen.

The members of this genus are grass-feeding species and occur in prairie habitats. Eight species are known to occur in North America. Two of these have been collected in Illinois, and others may be found here.

KEY TO SPECIES

Head broad, front convex transversely; elytra more than half the length of abdomen in both sexes.....**1. platyrhynchus**

Head narrow, front strongly concave for its entire length; elytra less than half the length of abdomen in both sexes.....**2. vanduzeei**

1. Dorycephalus platyrhynchus Osborn

Dorycephalus platyrhynchus Osborn (1894, p. 216).

Fig. 189. Length of male 9-10 mm., female 14-15 mm. Female yellowish to brown-

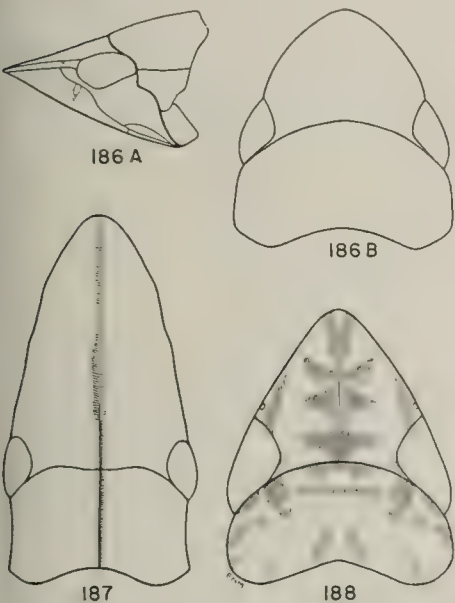


Fig. 186.—*Parabolocratrus viridis*. A, lateral aspect; B, dorsal aspect of head and thorax.

Fig. 187.—*Neoslossonia putnami*, dorsal aspect of head and pronotum.

Fig. 188.—*Dicyphonia ornata*, dorsal aspect of head and pronotum.

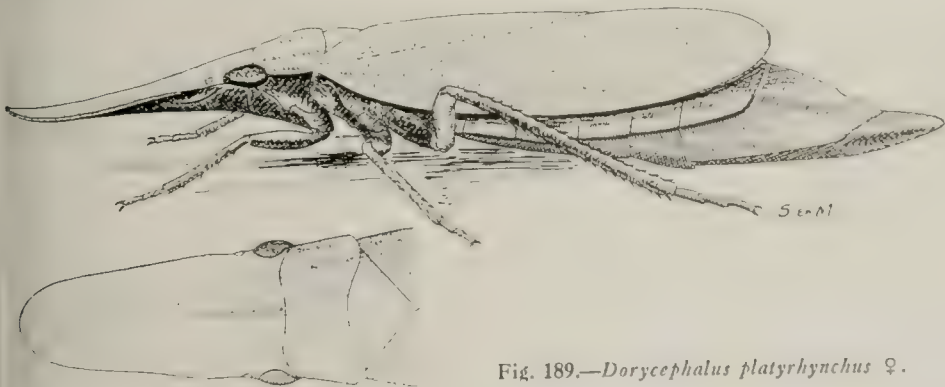


Fig. 189.—*Dorycephalus platyrhynchus* ♀.

ish, resembling a dried blade of grass; with a long foliaceous head having a median keel; vertex almost two and one-half times as long as basal width, broad to apex, which is broadly rounded. Elytra of female short, exposing the last three segments of the abdomen. Male usually brown, vertex about one and one-half times as long as basal width between eyes; elytra usually reaching tip of abdomen.

Female seventh sternite broadly and shallowly emarginate, almost truncate, with a short rounded median tooth. Male plates as long as combined basal width, concavely narrowed to blunt apices. Valve short and broad. Pygofers twice as long as plates.

This is a typical prairie species occurring on grasses of the prairie association. Recorded from two species of *Elymus* in Iowa, it is known from the Middle West ranging from Illinois to Colorado.

Illinois Records.—DECATUR: June 12–29, 1935, Frison, Mohr, & DeLong, 21 ♂, 8 ♀. HILLSDALE: June 5, 1940, Mohr & Burks, 1 ♂. ROCKFORD: July 5, 1932, Dozier & Mohr, 1 ♂. SUMMIT: July 17, 1935, DeLong & Ross, 1 ♀.

2. *Dorycephalus vanduzeei* Osborn & Ball

Dorycephalus vanduzeei Osborn & Ball (1898, p. 74).

Length 13–14 mm. Extremely long, slender, with thin flat head. Yellowish to green, marked with black spots. Entire insect is about 10 times as long as broad. Vertex three times as long as pronotum, foliaceous, apex broad, rounded, slightly elevated; front broadly, concavely, longitudinally depressed. Elytra short, reaching only to base of third abdominal segment, apices narrowed, rounded, and divergent. The abdominal segments each bear four small spots on the dorsal surface arrayed in two longitudinal rows. A lateral row each side is formed by a larger spot at the lateral line on each segment. Female seventh sternite long, almost truncate; male pygofers stylelike and very elongated.

This species occurs on the short grass, *Sporobolus cuspidatus*, and it has also been taken from the *Aristida purpurea* association. It has been previously recorded from Florida, Colorado, Kansas, and Nebraska.

Illinois Record.—OAK LAWN: July 11, 1945, DeLong & Ross, 1 ♂, 1 ♀.

31. *NEOSLOSSONIA* Van Duzee

Neoslossonia Van Duzee (1909a, p. 218).

Vertex obtusely triangular, almost flat, having a broad median longitudinal furrow, at either side of which is an elevated ridge. Pronotum with a median carina. Head as long as width at base; head and pronotum coarsely punctate.

Only one species of this genus, *putnami*, has been described, and it has been taken in Georgia and Florida. It has not been taken in Illinois, but in view of the peculiar occurrence of several typical Florida species in an area of the old Lake Michigan basin south and west of Chicago, it seems possible that it might at some time be found in that area of the state.

1. *Neoslossonia putnami* (Osborn)

Dorycephalus putnami Osborn (1907, p. 163).

Fig. 187. Length 5.5 mm. Broad, flat-headed, black, without color markings. Vertex almost flat, about as long at middle as basal width between eyes, with a broad median furrow. Vertex and pronotum coarsely punctate. Elytra reaching almost to tip of abdomen, minutely punctate. Male valve broad and short, triangular. Plates triangular, elongate, slender, acute at apices, about half as long as pygofers.

This species has been found on marsh grasses.

32. *HECALUS* Stål

Hecalus Stål (1864, p. 65).

Glossocratus Fieber (1866, p. 502).

Vertex longer than basal width, flattened, sharp and foliaceous at margin. Pronotum very short and broad. Clavus of each elytron with at least two veins. Elytra shorter than abdomen.

The members of this genus inhabit marshes, where they feed upon coarse grasses and sedges. Four species are known for the United States, and one of them is found in Illinois.

1. *Hecalus lineatus* (Uhler)

Glossocratus lineatus Uhler (1877, p. 463).

Fig. 190. Length of female 9 mm., male 7 mm. Long, broad, greenish, with a long thin flat vertex; four longitudinal bright

red stripes extending across vertex and pronotum, the central pair crossing scutellum. Elytra short in female, greatly exceeded by abdomen, nervures broadly reddish or yellowish; in the male, the elytra a little ex-

in front. Scutellum short. Elytra each with four apical cells.

One of the three Nearctic species of this genus occurs in Illinois on short grasses.

1. *Spangbergiella quadripunctata* Lawson

Spangbergiella quadripunctata Lawson (1932b, p. 120).

Length 6.0–6.5 mm. Sharp headed, green; vertex and pronotum green or greenish yellow, with two oblique divergent red stripes extending from near the apex of vertex to basal angles of scutellum. Vertex a little longer than basal width, roundedly angulate. Pronotum with a short median red stripe on posterior half. Each elytron with four parallel oblique red bands extending from costal area almost to inner margin.

Female seventh sternite truncate posteriorly. Male valve nearly concealed; each plate broad at base, abruptly narrowed, and produced into long point. The female is usually more yellow in color and less intensely marked with red.

This is a very common species on grasses in low moist meadows or in grassy woodlands. It is widely distributed over the Middle West, and occurs also in some of the eastern states.

Illinois Records.—CAVE IN ROCK: Oct. 2, 1934, Frison & Ross, 3 ♀; July 9, 1934, DeLong & Ross, 5 ♂, 8 ♀. DIXON SPRINGS: July 29, 1934, DeLong & Mohr, 1 ♂, 1 ♀; July 9, 1935, Ross & DeLong, 3 ♂, 3 ♀. FERN CLIFF: Aug. 3, 1934, DeLong & Mohr, 1 ♂. KARNAK: Aug. 8, 1934, Ross, DeLong, & Mohr, 1 ♂, 1 ♀. OLIVE BRANCH: Aug. 2, 1934, DeLong & Mohr, 1 ♀. VIENNA: June 14, 1934, DeLong & Ross, 1 ♀; July 29, 1934, DeLong & Ross, 2 ♂, 2 ♀.

34. *PARABOLOCRATUS* Fieber

*Parabolocratu*s Fieber (1866, pp. 502, 513).

Fig. 186. Head flattened, well produced, usually narrower than pronotum, with a definite margin, which is often thin and foliaceous; ocelli on margin near the eyes. Elytra macropterous in both sexes and often brachypterous in female.

Twenty species have been found in the United States; of these six are known to occur in Illinois. All of the species are found in marsh habitats on tall grasses.

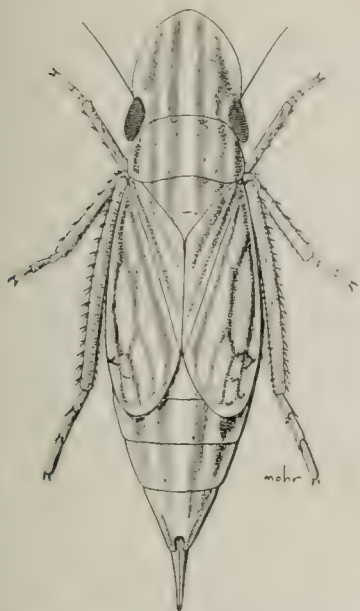


Fig. 190.—*Hecales lineatus* ♀.

ceeded by the black abdomen and usually crossed by two broad black bands, one across middle and another covering apexes and a part of anteapical cells. Female seventh sternite long, slightly produced at center, appearing like a small lobe. Male plates long, triangular, acutely pointed.

This species ranges from New York west to Kansas, North Dakota, and Colorado. It is abundant in the marshes of the northern one-fourth of Illinois.

Illinois Records.—Males and females, taken May 4 to August 23, are from Alsip, Bement, Champaign, Fox Lake, Kankakee, La Grange, Normal, Oak Lawn, St. Anne, Summit, Tolono, Waukegan, and Zion.

33. *SPANGBERGIELLA* Signoret

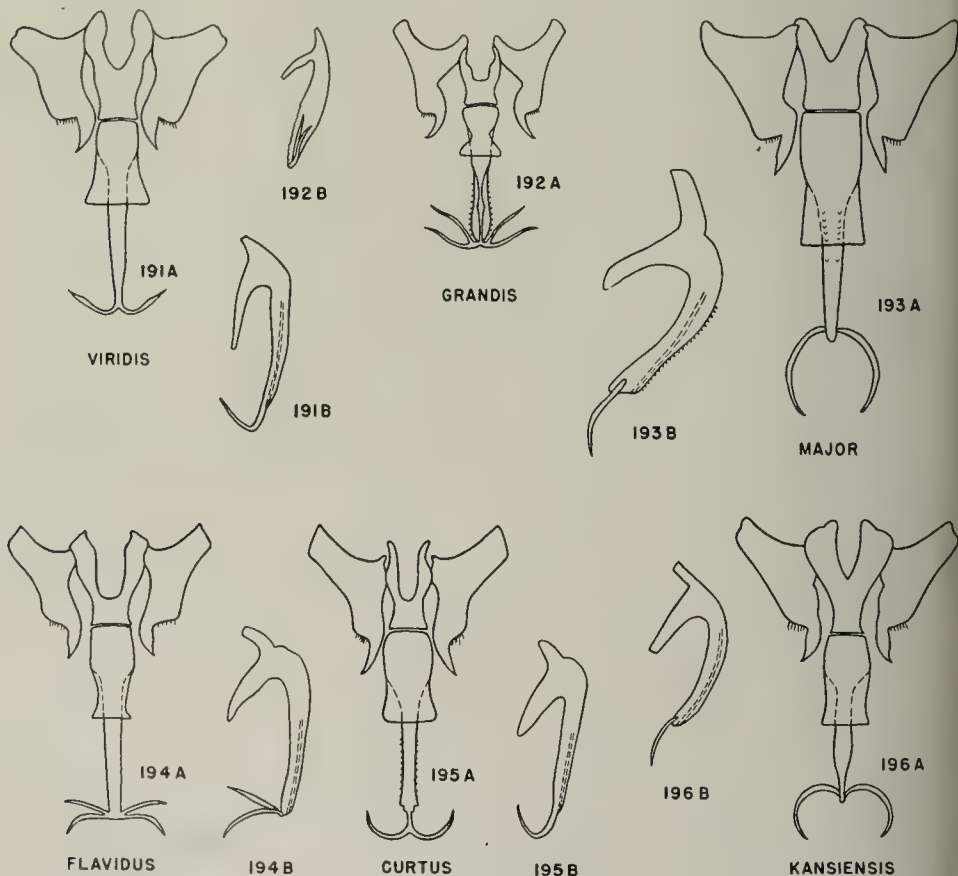
Spangbergiella Signoret (1879, p. 273).

Fig. 185. Head strongly produced before the eyes, triangular, ocelli on sharp margin near the eyes. Front rather broad, convex, cheeks with oblique angles rounded. Pronotum twice as wide as long, slightly rounded

KEY TO SPECIES

1. Females.....8
Males.....2
2. Vertex margin thin, usually foliaceous at apex, usually marked with a brown line just beneath margin. Apical portion of aedeagus with a pair of unbranched lateral processes, as in fig. 191.....3
Vertex margin thicker, not thin or foliaceous at apex, usually without a brown line beneath margin. Apical portion of aedeagus with a pair of branched processes.....7
3. Male pygofers each broadly rounded apically, not concavely rounded to the produced apical dorsal lobe nor notched on ventral margin near apex; apex of aedeagus as in fig. 193.....**1. rotundus**
Male pygofers each concavely rounded on caudal margin to the produced apical dorsal lobe, or notched on ventral margin near apex, or both.....4
4. Lateral processes of aedeagus arising apically, as in fig. 191.....5
Lateral processes of aedeagus arising

- laterally just before apex, as in fig. 193.....6
5. Vertex bluntly produced, about as long as pronotum and at least two-thirds as long as width between eyes.....**2. viridis**
Vertex more broadly rounded, about two-thirds as long as pronotum, and about one-half as long as median width between eyes.....**3. curtus**
 6. Margin of vertex broadly rounded, about two-thirds as long at middle as basal width. Each pygofer with a prominent notch on ventral margin near apex.....**4. major**
Margin of vertex angulate at apex, slightly wider between eyes than median length. Each pygofer scarcely notched on ventral margin near apex.....**5. kansiensis**
 7. Aedeagus, fig. 194, tapering on apical half to the bifurcate apical processes, which are about equal in length and widened at middle. Apexes of elytra usually brownish.....**6. flavidus**
Aedeagus, fig. 192, roundedly enlarged before apex, then rapidly narrowed to



Figs. 191-196.—*Parabolocratas*, male genitalia. A, ventral aspect; B, lateral aspect of aedeagus. (Redrawn after Shaw.)

the apical bifurcate processes; inner process of each pair considerably longer than the outer. Elytra usually entirely green.....7. **grandis**

8. Vertex as long as or longer than wide.....7. **grandis**

Vertex wider than long.....9

9. A brown line below margin of vertex...10
Without a brown line below margin of vertex.....11

10. Elytra exceeding ovipositor, vertex at middle distinctly shorter than pronotum.....3. **curtus**

Elytra at least exceeded by tip of ovipositor; vertex about the same length as pronotum.....2. **viridis**

11. Vertex broadly rounded at apex; face appearing in profile rather strongly inflated.....4. **major**

Vertex angularly produced; face scarcely inflated, almost straight.....12

12. Margin of vertex foliaceous; each elytron uniformly greenish but occasionally with small brown spot at tip of clavus.....5. **kansiensis**

Margin of vertex thin but not foliaceous; each elytron with a small brown spot at tip of clavus and another at apex of fourth apical cell.....6. **flavidus**

1. *Parabolocratus rotundus* DeLong

Parabolocratus rotundus DeLong (1938d, p. 302).

Length of male 7 mm. Female not known. Color greenish without definite markings. Resembling *major* in form and appearance, but with broadly rounded pygofers. Vertex one-half wider than median length, a little longer than pronotum. Face strongly inflated. Elytra exposing only the pygofers. Male plates about one-half longer than combined basal width, not quite so long as pygofers, which are broadly rounded posteriorly and without a preapical notch on ventral margin. Aedeagus stout, in lateral view decidedly narrowed before apex; apex expanded and bearing a rather long stout lateral process on either side of expanded portion before apex, similar to fig. 193 for *major*. The rounded pygofers will immediately separate this species from any other species of the genus. In the other species, the pygofers are concavely rounded on caudal margins to produced apical lobes, or notched on ventral margins.

This species is known from Illinois and Ohio only.

Illinois Records.—DES PLAINES: Sept. 18, 1935, DeLong & Ross, 1 ♂. ZION: July 25, 1934, Frison & DeLong, 1 ♂; Aug. 7, 1935, DeLong & Ross, 3 ♂.

2. *Parabolocratus viridis* (Uhler)

Glossocratus viridis Uhler (1877, p. 462).

Length of male 5.0–6.3 mm., female 6.5–8.5 mm. Large, yellowish green to bright green, with broadly rounded vertex. Vertex shorter than basal width; a brown line, frequently very short, below margin of vertex. Pronotum about the same length as vertex, sometimes slightly longer. Elytra of male extending beyond abdomen; of female exposing one or two abdominal segments (brachypterous) or only the ovipositor (macropterous). Costal margins of elytra usually whitish, apical portions brownish.

Female seventh sternite with posterior margin slightly and roundedly produced or truncate. Male valve broad and triangular. Plates about as long as combined basal width, slightly exceeded in length by pygofers, which are notched on ventral margins near apexes. Aedeagus, fig. 191, tapered to apex, which bears a pair of apical terminal lateral processes.

This species is widely distributed throughout the northern states.

Illinois Records.—Many males and females, taken May 7 to September 21, are from Alsip, Amboy, Antioch, Aurora, Cedar Lake, Champaign, Chemung, Decatur, Downs, Eichorn, Elgin, Evergreen Park, Fox Lake, Fulton, Ingleside, Jonesboro, Kimmund, Kirkwood, Lake Villa, Mayview, Oak Lawn, Ogden, Oquawka, Orangeville, Port Byron, Princeton, Putnam, St. Anne, Sheffield, Sparta, Spring Grove, Sun Lake, Urbana, Volo, Waukegan, and Zion.

3. *Parabolocratus curtus* Shaw

Parabolocratus curtus Shaw (1932, p. 41).

Length 5.5–6.5 mm. Yellowish green, a dark brown line below margin of vertex in both sexes. Vertex shorter than in *viridis*, much shorter than wide, in male about one-half as long as width between eyes. Pronotum in female a little longer than vertex, in male one-third longer than vertex; lateral margins white. Elytra exceeding abdomen in both sexes; costal margins whitish, apical margins brownish.

Female seventh sternite with posterior margin roundedly produced. Male valve broad and triangular. Plates a little longer than combined basal width. Pygofers a little longer than plates, with a distinct

notch on ventral borders just before apices. Aedeagus, fig. 195, with a pointed projection on either side before apex and a pair of terminal lateral curved processes.

This species, described from Kansas, probably occurs in the western portion of Illinois.

4. *Parabolocratrus major* Osborn

Parabolocratrus major Osborn (1915, p. 110).

Length of male 6.0–6.8 mm., female 7.5–9.0 mm. Yellowish green to green, markings variable. Rather large, round headed, larger and with a broader head than that of *viridis*. Vertex shorter than broad, margin broadly rounded. Pronotum longer than vertex in male, shorter than vertex in female. Elytra of female exposing the last two abdominal segments; elytra of male exceeding length of abdomen.

Female seventh sternite with posterior margin slightly produced. Male valve broad and triangular. Plates a little longer than combined basal width. Pygofer a little longer than plates, ventral margins deeply notched close to apices. Aedeagus, fig. 193, stout, rather broad in lateral view, not narrowed apically; it bears a pair of long lateral processes before apex.

This species is found in the eastern United States and ranges west to Colorado.

It has been taken most commonly in Illinois in *Calamagrostis* meadows and similar marsh habitats.

Illinois Records.—Males and females, taken June 10 to September 6, are from Antioch, Des Plaines, Evergreen Park, Fox Lake, Grays Lake, Oak Lawn, St. Anne, Summit, Volo, Wauconda, and Zion.

5. *Parabolocratrus kansiensis* Shaw

Parabolocratrus kansiensis Shaw (1932, p. 47).

Length of male 5.5–5.0 mm., female 8.0 mm. Rather large, pale green, a brown line below margin of vertex in both sexes. Head angulate, vertex wider between eyes than median length, margin decidedly foliaceous. Pronotum in male about equaling vertex in length, in female shorter than vertex. Elytra of female exposing one or two abdominal segments; elytra exceeding length of abdomen in male.

Female seventh sternite with posterior margin broadly rounded. Male valve broad,

triangular, plates about one-fourth longer than combined basal width. Pygofer exceeding length of plates, very faintly notched on ventral margins before apices. Aedeagus, fig. 196, in ventral view strongly narrowed apically and bearing a pair of unbranched processes before apex. Processes evenly curved inwardly.

This species is western in distribution and has been taken only from a marsh in the extreme western portion of the state.

Illinois Record.—LIMA: July 29, 1936, Mohr & Burks, 1 ♂, 2 ♀.

6. *Parabolocratrus flavidus* Signoret

Parabolocratrus flavidus Signoret (1879, p. 276).

Length of male 4.5–6.0 mm., female 5.5–8.0 mm. Pale green to yellowish green, with angulate head. Vertex in both sexes shorter than wide, but more angulate in the male. Face pale orange below apex. Pronotum as long as vertex. Elytra of female exposing one or two abdominal segments or, in long-winged forms, reaching tip of ovipositor; in male the elytra exceed the abdomen; each elytron usually with a small brown spot at apex of clavus and another at end of fourth apical cell.

Female seventh sternite with posterior margin gradually produced. Male valve short and very narrow. Plates strongly and concavely narrowed apically, a little longer than basal width. Pygofer a little longer than plates, each tapered to pointed apex, not concavely rounded on ventral apical margin. Aedeagus, fig. 194, long in ventral view, with margins tapered to apex, which bears a pair of bifurcate processes on either side; two branches of each process about equal in length.

This species is found in the southeastern states and ranges into Arkansas and Kansas. It is common in the southern portion of Illinois, but has been taken only rarely in the northern half.

Illinois Records.—CARBONDALE: July 16, 1909, 1 ♀. CAVE IN ROCK: July 9, 1935, DeLong & Ross, 8 ♂, 3 ♀. DIXON SPRINGS: July 9, 1935, DeLong & Ross, 1 ♂, 1 ♀. DONGOLA: on juniper, May 11, 1917, 1 ♂. EVERGREEN PARK: July 1, 1935, DeLong & Ross, 1 ♀. THEBES: on cane, July 11, 1935, DeLong & Ross, 1 ♂. URBANA: Sept. 1, 1889, 1 ♂.

7. *Parabolocratius grandis* Shaw

Parabolocratius grandis Shaw (1932, p. 44).

Length of male 5.0–7.0 mm., female 7.5–9.0 mm. Yellowish green, elytra with a small dark brown spot at apex of each clavus. Vertex of female as long as or longer than wide, anterior margin rather broadly rounded; vertex of male wider between eyes than median length, more angulate apically. Pronotum of female much shorter than vertex; pronotum of male as long as vertex. Elytra of female very short, exposing the last four or five abdominal segments; elytra of male long, covering abdomen.

Female seventh sternite with posterior margin truncate or slightly produced medially. Male valve concealed, plates a little longer than basal width, exceeded by pygofers, which are tapered to acutely pointed apices, slightly concave on caudoventral margin. Aedeagus, fig. 192, short, in ventral view roundedly broadened before constricted apex, which bears a pair of bifurcate lateral processes, the inner branch of each longer than outer branch.

This species has been collected in the tall grasses in the marsh habitats of the Chicago area. It is recorded from Florida, Alabama, Texas, and Kansas.

Illinois Records.—EVERGREEN PARK: Aug. 23, 1934, DeLong & Ross, 2 ♀; July 1, 1935, DeLong & Ross, 7 ♂, 1 ♀. SUMMIT: July 17, 1936, DeLong & Ross, 1 ♂, 5 ♀; Aug. 21, 1936, DeLong & Ross, 2 ♀.

35. *DORYDIELLA* Baker

Dorydiella Baker (1897, p. 159).

Fig. 183. Vertex produced, roundedly angulate, foliaceous and upturned at apex; ocelli on margin next to the eyes. Head depressed, longer than pronotum. Elytra long, with apices acutely angled, each with four apical cells and two anteapicals; each clavus with two longitudinal veins.

Two species have been described or placed in this genus.

1. *Dorydiella kansana* Beamer

Dorydiella kansana Beamer (1945, p. 48).

Length 8 mm. Large, yellowish, with brown markings, superficially resembling a *Paraphlepsius* such as *ramosus*. Vertex flat,

margin foliaceous and with brown spots. Face irrorate. Pronotum with brown longitudinal striae. Elytra long, apices acutely angled; ramose pigmented lines arranged longitudinally between the veins; a brown spot at apex of each elytron.

Female seventh sternite with three short rather broad V-shaped notches on the posterior margin and appearing serrate. Male plates triangular, pointed, almost as long as combined basal width. The nymphs have a long flat vertex similar to that of *Dorycephalus* adults, but during development to maturity this becomes shorter and forms a rather broad roundedly angled vertex.

The species has been found abundantly at the margins of lagoons along the shores of the Great Lakes, where it lives in the *Scleria-Eleocharis* association. It also occurs on small plants in the fresh-water marsh but less abundantly.

Illinois Records.—PRINCETON: swamp, July 7, 1934, DeLong & Ross, 4 nymphs. SHAWNEETOWN: June 27, 1936, DeLong & Mohr, 2 nymphs. WAUKEGAN: Aug. 5, 1935, Ross & DeLong, 1 ♂, 2 ♀. ZION: July 25, 1934, Frison & DeLong, 1 ♂.

36. *DICYPHONIA* Ball

Dicyphonia Ball (1900a, p. 69).

General form of *Parabolocratius*; vertex narrower, shorter, and more angular than in *Hecalus*. Disc of vertex concave, margins sharp, slightly foliaceous. Ocelli on margin close to eyes. Pronotum as wide as head across eyes and broadly rounded anteriorly.

Five species belonging to this genus are now listed for North America by Beamer (1936a); none of these has been collected in Illinois. In view of its known distribution, *ornata* may be found in the western portion of the state. All five species are apparently western in distribution.

1. *Dicyphonia ornata* (Baker)

Platymetopius ornatus Baker (1900b, p. 49).

Dicyphonia ramentosa Ball (1900a, p. 69).

Fig. 188. Length 5.25 mm. Yellowish, with produced vertex, rounded at apex and three-fourths as wide between eyes as median length. Vertex with a pair of dark spots behind apex, these usually fused; posterior to this are three abbreviated transverse bands, which are fused medially so as

to form a broad irregularly outlined longitudinal band. Pronotum with two short transverse bars anteriorly, and irregular dark markings on lateral portions. Elytra smoky on posterior portion, each with white spots. Male plates small, each broad at base, suddenly narrowed beyond middle into slender acute apex.

This species has been collected in Kansas, Colorado, and Utah.

Subfamily APHRODINAE

Although the genera of this group vary considerably in size and shape, all have the ocelli distant from eyes, and, except in *Xestocephalus*, the ocelli are just above the margin of the vertex. Four genera are recorded in this subfamily for the United States, and three of these have been taken in Illinois.

KEY TO GENERA

1. Vertex rather flat, with acute margin forming definite limitations of vertex and front, fig. 32.....2
Vertex sloping and rounding to front, with thick margin, or without definite margin, fig. 197.....3
2. Vertex transversely striate behind front margin between each eye and ocellus; length 5.0 to 6.0 mm.....37. *Stroggylocephalus*
Vertex granulate behind front margin between each eye and ocellus; length 3.0 to 4.5 mm. Females of.....38. *Aphrodes*
3. Vertex nearly evenly rounded to front, with each ocellus about midway between eye and apex of vertex, fig. 197; pronotum extremely, finely, transversely wrinkled.....40. *Xestocephalus*
Vertex more flattened and distinctly angled with front, as in fig. 32; pronotum conspicuously, transversely wrinkled.....4
4. Each ocellus close to eye, about one-fourth distance between it and apex of vertex; width of vertex about one and one-half times its length, fig. 198.....39. *Memnonia*
Each ocellus about one-half distance between eye and apex of vertex; width of vertex nearly twice its length. Males of.....38. *Aphrodes*

37. *STROGGYLOCEPHALUS* Flor

Stroggylocephalus Flor (1861, p. 210).

Vertex produced, obtusely angled, transversely striate in front. Margin foliaceous, ocelli close to front margin. Elytra coriaceous, each narrowly rounded at apex, coarsely punctate, appendix absent.

Only one northern species of this genus is known to occur in the United States.

1. *Stroggylocephalus agrestis* (Fallen)

Cicada agrestis Fallen (1806, p. 23).

Tettigonia mixta Say (1825, p. 341).

Length 6-7 mm. Grayish yellow to dark brown, frons black, finely irrorate with pale brown. Vertex striate in front, smooth at base. Pronotum transversely striate. Elytra with the inner margins, bars and spots along nervures, and 12 or more spots on each costa brown or blackish. The female is usually paler than male and with fewer markings. Female seventh sternite concave, notched at middle.

This species occurs in moist grassy areas from New York to Colorado.

Illinois Records.—NORMAL: March 27, 1884, 2 ♀. CARY: grassy marsh, Nov. 26, 1946, Ross & Burks, 1 ♂, 1 ♀.

38. *APHRODES* Curtis

Aphrodes Curtis (1833, p. 195).

Acucephalus Germar (1833, p. 181).

Pholetaera Zetterstedt (1838, col. 288).

Anoscopus Kirschbaum (1858b, p. 357).

Fig. 32. Vertex obtusely angular, produced, in female usually tricarinate. Ocelli on front margin a little nearer the eyes than the apex.

Five species of this genus occur in the United States, all eastern in distribution. One species is known from Illinois.

1. *Aphrodes albifrons* (Linnaeus)

Cicada albifrons Linnaeus (1758, p. 437).

Cicada nitidula Donovan (1799, p. 87, pl. 288, fig. 1).

Aphrodes concinna Curtis (1837, pl. 633).

Aphrodes testudo Curtis (1837, pl. 633).

Pholetaera nigropunctata Zetterstedt (1838, col. 288).

Pholetaera livens Zetterstedt (1838, col. 288).

Acucephalus interruptus Scott (1873, p. 264).

Acucephalus polystolus Scott (1873, p. 265).

Acucephalus circumflexus Provancher (1889, p. 282).

Length 3-4 mm. Rather small, variable in color, yellowish to brown, front pale. Female usually irrorate with black or brown; male with white spots on elytra, often in the form of large blotches or transverse bands. In the male, the elytra are usually shorter, exposing the tip of the abdomen.

Female seventh sternite with posterior

margin broadly and angularly emarginate to a central short U-shaped notch. Male plates more than twice as long as basal width, convexly narrowed on inner margins to bluntly pointed apices; inner margins contiguous, outer margins straight, causing plates to bend to a vertical position at apices.

This species ranges from New York to Wisconsin. It has an unusual habit for a member of the leafhopper group. Normally subterranean, it feeds for the most part upon grass roots. However, it has been swept from vegetation. Its distribution may be much wider than the records indicate.

Illinois Records.—Many males and females, taken June 9 to August 28, are from Algonquin, Apple River Canyon State Park, Chicago, Dolson, Kankakee, Mokena, St. Joseph, Starved Rock State Park, Sun Lake, Urbana, and Waukegan.

39. *MEMNONIA* Ball

Memnonia Ball (1900a, p. 66).

Fig. 198. In general form similar to *Aphrodes*, and with a convex sloping vertex, which has a rather thick margin. Ocelli on margin, distant from the eye. Face forming an acute angle with the vertex. Pronotum as long as vertex, strongly and transversely wrinkled. Macropterous and brachypterous forms.

Five species of this genus are listed for North America, but none of these has been taken in Illinois. Since two of them occur in the states just west of Illinois, and they are short grass species, it is possible they may be collected at some future time in Illinois.

1. *Memnonia consobrina* Ball

Memnonia consobrina Ball (1900a, p. 66).

Length of male 3.0 mm., female 4.0–4.25 mm. Resembling *Aphrodes* in general form and appearance. Vertex roundedly produced, twice as wide between eyes as median length in female; vertex more pointed in male. Both macropterous and brachypterous forms are known. Female with vertex, pronotum, and scutellum green or yellowish green, elytra brownish or dark green, with nervures brown; face black to green, abdomen black. Male shiny black, eyes pale; elytra each with three or four white spots in a row across anteapical cells.

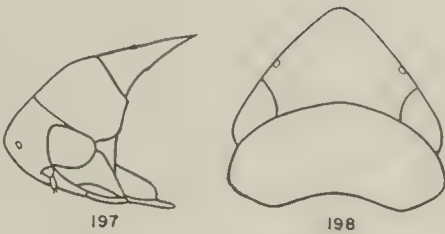


Fig. 197.—*Xestocephalus pulicarius*, lateral aspect of head and thorax.

Fig. 198.—*Memnonia consobrina*, dorsal aspect of head and thorax.

Female seventh sternite with posterior margin shallowly emarginate, bearing a median blunt tooth. Male valve scarcely visible. Plates only about half as wide at base as preceding segment, about three times as long as basal width, narrowed to acute tips.

This is a grass-feeding species that occurs on the prairie. It has been found abundantly in Colorado and Nebraska.

40. *XESTOCEPHALUS* Van Duzee

Xestocephalus Van Duzee (1894b, pp. 197, 214).

Fig. 197. General form ovate, head narrower than pronotum, subconical, vertex convex, sloping. Ocelli on anterior margin, distant from eyes. Antennae close to eyes. Elytra appearing rugose, without appendix, and with several apical areolate spots.

All of the species are small, usually not exceeding 4 mm. With few exceptions they are similar in color, and the genital structures of all the species are quite similar for either sex. As a result they are difficult to separate.

Peters (1933) and Knull (1944) record 14 species in this genus for the United States, most of which are found in the East. Four species have been collected in Illinois, and at least two others may occur here.

KEY TO SPECIES

- 1. Vertex with distinct markings in the form of lines or spots.....2
Vertex without distinct markings, with areas of uniform coloration.....3
- 2. Pronotum brown, with a broad white transverse band on posterior half, fig. 199.....1. *coronatus*
Pronotum brown, marked with pale spots, without transverse band.....2. *pulicarius*
- 3. Length 4.0 mm.; black in color.....3. *piceus*

- Length not exceeding 3.75 mm.; brown or black. 4
4. Black in color. **4. nigrifrons**
Brown in color. 5
5. Vertex pale brown; elytra brown, with a few hyaline markings near apices. Length about 2 mm. **5. brunneus**
Vertex pale brown, often with faint markings. Length 3 mm. or more. **6. superbus**

1. *Xestocephalus coronatus* Osborn & Ball

Xestocephalus coronatus Osborn & Ball (1897, p. 184).

Fig. 199. Length 2.5–3.0 mm. Vertex roundedly produced, about half as long as basal width between the eyes. Color white, with a large brown spot encircling each ocellus and extending two-thirds the length of vertex, leaving a median white longitudinal area, which is slightly divided by a brownish crossband back of apex. Face pale brown. Pronotum one-third longer than vertex, dark brown, with a broad white transverse band on posterior half. Scutellum brown, apical half paler. Elytra brown, each with paler areas, especially on the apical third; portions of veins on clavus and corium white.

This species is recorded from Iowa, Nebraska, and Wisconsin. Although only one specimen has been taken in Illinois, the species undoubtedly has a wider distribution in the state than this single collection indicates.

Illinois Record.—MARSHALL: Sept. 27, 1934, Frison & Ross, 1 ♀.

2. *Xestocephalus pulicarius* Van Duzee

Xestocephalus pulicarius Van Duzee (1894b, pp. 197, 215).

Length 2.5–3.0 mm. Small, brown, with distinct and conspicuous pale markings. Vertex rounded, with fulvous apex; a yellow line next to each eye extending toward apex, and a yellow line on posterior margin from which two lines extend forward and curve on disc; pronotum as long as vertex. Elytra marked with many white spots. Female seventh sternite emarginate, with a slightly produced lobe on either side. Male plates tapered beyond the middle to obtuse apices.

Peters (1933) separated and described several new species of *Xestocephalus*. He

separated *similis* from *pulicarius* on the basis of a hooked process on the heel of the foot-shaped terminus of the style. In the present series of Illinois material, there are all gradations of this process from the process in the form he has designated as *pulicarius* to the strongly produced process he illustrated for *similis*. If *similis* is a distinct form, the character of the style cannot adequately be used for the separation of these species. It is the writer's opinion that *pulicarius* is a species with a great number of color variations that cannot be separated from one another by structural characters.

This is the most common species of the genus in Illinois and occurs on herbaceous



Fig. 199.—*Xestocephalus coronatus*. (From Osborn.)

vegetation, especially at the edge of woodland or in open wooded areas. It ranges from the eastern United States west to Utah.

Illinois Records.—Many males and females, taken March to November 13, are from Adair, Albion, Algonquin, Apple River Canyon State Park, Cave in Rock, Champaign, Clayton, Danville, Dolson, Dongola, Dubois, Fulton, Geff, Grand Detour, Havana, Herod, Hopedale, Horseshoe Lake, Kankakee, Karnak, La Grange, Marshall, Muncie, Oak Lawn, Oakwood, Olive Branch, Oquawka, Palos Park, Pere Marquette State Park, Pike, Pittsfield, Putnam, Rock Island, St. Anne, Sugar Grove, Temple Hill, Thebes, Urbana, Vienna, Volo, White Heath, White Pines Forest State Park, and Wilmington.

3. *Xestocephalus piceus* Osborn

Xestocephalus piceus Osborn (1928, p. 244).

Length 4 mm. Mostly black, with apex of vertex and upper part of face dark brown; elytra with paler spots on each

costa near apex. Vertex about twice as long at middle as length next to eyes. Genitalia not differing from those of other species in the genus. Pronotum a little longer than vertex.

This species occurs in southern Ohio and may be taken in Illinois in future collections.

4. *Xestocephalus nigrifrons* Osborn

Xestocephalus nigrifrons Osborn (1915, p. 109).

Length 3 mm. Mostly black, as in *piceus*, but with a black face and smaller in size. This species may be only a very dark form of *pulicarius*, which is quite variable in color pattern. Although *nigrifrons* has not been collected in Illinois, specimens that are considered as *nigrifrons* have been found in Tennessee, and other specimens of this species might possibly be taken at some time in the southern portion of Illinois. It is also recorded from Maine.

5. *Xestocephalus brunneus* Van Duzee

Xestocephalus brunneus Van Duzee (1907, p. 62).

Length 2 mm. Small, pale brown, without markings on the vertex. Vertex short, rounded, less produced than in *pulicarius*. Pronotum pale brown behind eyes. Each elytron dark at base, without spots, apical half paler, with spotted areas; quadrate spot on middle of costa, a smaller and darker one beyond this, and the apex broadly darker; two pale spots beyond the clavus along the sutural margin. Male genitalia similar in structure to those of other species of the genus.

Specimens that are identified as of this species have been taken in Illinois from herbaceous vegetation. The range of this species is in the eastern United States.

Illinois Records.—APPLE RIVER CANYON STATE PARK: July 11, 1934, DeLong & Ross, 1 ♀; June 29, 1935, DeLong & Ross, 4 ♀. EICHORN: May 11, 1935, Mohr, 4 ♂, 2 ♀. GRAFTON: along river, June 26, 1934, DeLong & Ross, 1 ♀. SPRINGFIELD: June 12, 1935, DeLong & Mohr, 2 ♂, 2 ♀. URBANA: June 20, 1915, 1 ♀; June 2, 1916, 1 ♂; June 17, 1916, 4 ♂; Sept. 12, 1934, Rice, 1 ♂. VIENNA: June 14, 1934, DeLong & Ross, 4 ♀.

6. *Xestocephalus superbis* (Provancher)

Deltocephalus superbis Provancher (1890, p. 339).

Xestocephalus fulvocapitatus Van Duzee (1894b, pp. 197, 215).

Length 3.5 mm. Pale yellowish to brownish, with faint markings on the head, median longitudinal line paler than remainder of head. Pronotum light brown, with numerous white spots. Scutellum with darker basal angles. Elytra light brown, with darker spots on apical and costal areas, each with two pale spots on claval suture. Genital characters not different from those of other species of the genus.

This species, common in Illinois on herbaceous growth in open wooded areas, is distributed through the eastern states.

Illinois Records.—Males and females, taken May 8 to October 2, are from Aldridge, Algonquin, Danville, Dolson, Dongola, Dubois, Elizabethtown, Goreville, Hopedale, Marshall, Oak Lawn, Savanna, Urbana, and Wilmington.

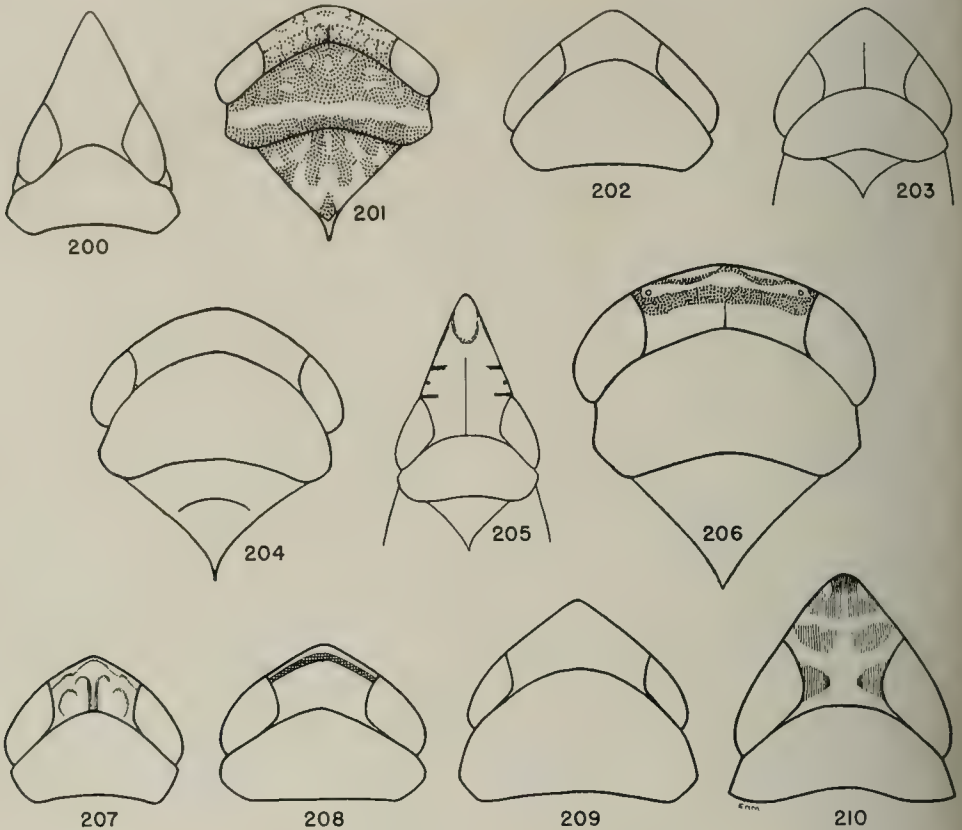
Subfamily ATHYSANINAE

All the members of this group have the ocelli on or very near the front margin of the vertex and close to the eyes. The length and degree of thickness of the margin vary greatly among the genera.

This subfamily contains about 90 genera in the Nearctic region, and it is the largest group in the Cicadellidae. Sixty-two genera are treated in this report.

KEY TO GENERA

1. Gena visible behind or below eye from dorsal view, fig. 200.....2
- Gena not visible behind eye from dorsal view, as in fig. 201.....4
2. Elytra each with one cross nervure between first and second sectors; only two veinlets reaching costal margin, fig. 211.....47. *Japananus*
- Elytra each with two cross nervures between first and second sectors, as in fig. 214; numerous veinlets reaching costal margin.....3
3. Pale brown, with a broad pale yellowish longitudinal stripe extending from apex of vertex to apex of clavus; male aedeagus, fig. 241, without a pair of long slender processes....48. *Scaphytopius*
- Brown or black, without a longitudinal yellow stripe from vertex to clavus; male aedeagus, figs. 300-325, with a dorsal process and a pair of long slender processes.....49. *Cloanthanus*



Athyisaninae heads and pronota

Fig. 200.—*Cloanthanus cuprescens*.

Fig. 201.—*Remadosus magnus*.

Fig. 202.—*Tropicanus costomaculatus*.

Fig. 203.—*Lonatura catalina*.

Fig. 204.—*Chlorotettix unicolor*.

Fig. 205.—*Acurhinus pyrops*.

Fig. 206.—*Limotettix divaricatus*.

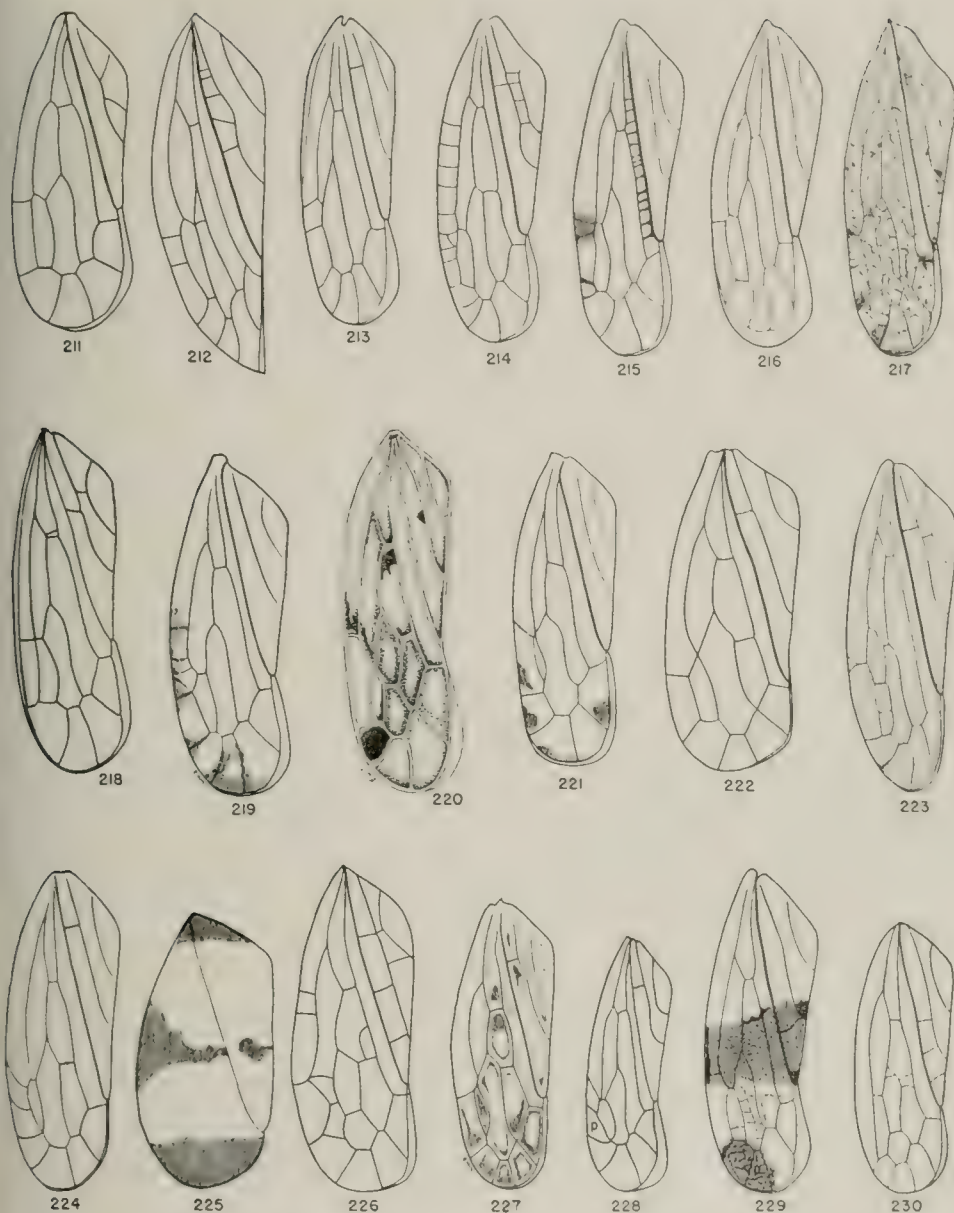
Fig. 207.—*Atanus perspicillatus*.

Fig. 208.—*Amplicephalus estacadus*.

Fig. 209.—*Thamnotettix simplex*.

Fig. 210.—*Gilletteiella atropuncta*.

4. Clypeus broadest at apex and constricted at base or broadly constricted at middle, as in fig. 231A.....6
- Clypeus usually parallel sided, or narrowed at apex, not broadest at apex, as in fig. 232A.....5
5. Elytra very short, exposing at least five abdominal segments, as in fig. 403; veins of each elytron, if not obscured, reaching apex or only rarely with short cells at apex of elytron, as in figs. 237C, 238C.....18
- Elytra long, usually covering abdomen; at least one larger closed cell before apex of each elytron.....35
6. Costal margin of each elytron evenly rounded to the straight inner margin so that apex appears pointed, fig. 212....89. **Acinopterus**
- Apex of each elytron rounded, not pointed.....7
7. Elytra marked with ramose pigment lines or vermiculate lines or merging spots or dots, as in fig. 217.....8
- Elytra with various color markings but without ramose or vermiculate pigment markings.....14
8. Markings on elytra in the form of a saddle or broken band, fig. 229; vertex short, with an impressed transverse furrow just back of anterior margin.....82. **Norvellina**
- Elytra without saddle markings, or vertex without a transverse furrow.....9
9. Vertex parallel margined and about four times as wide as median length, fig. 201.....83. **Remadosus**
- Vertex longer at middle than next to eyes, fig. 202, and not more than three times as wide as long.....10
10. Head at least as wide as pronotum.....11
- Head narrower than pronotum.....12



Athysaninae elytra. Abbreviation: "p" = postnodal cell.

Fig. 211.—*Japananus hyalinus*.

Fig. 212.—*Acinopterus acuminatus*.

Fig. 213.—*Davisonia major*.

Fig. 214.—*Aligia modesta*.

Fig. 215.—*Prescottia lobata*.

Fig. 216.—*Exitianus obscurinervis*.

Fig. 217.—*Paraphlepsius tenessa*.

Fig. 218.—*Bandura johnsoni*.

Fig. 219.—*Menosoma cincta*.

Fig. 220.—*Arundanus proprius*.

Fig. 221.—*Palus delector*.

Fig. 222.—*Latulus sayi*.

Fig. 223.—*Fieberiella florii*.

Fig. 224.—*Flexamia inflata*.

Fig. 225.—*Unoka ornata*.

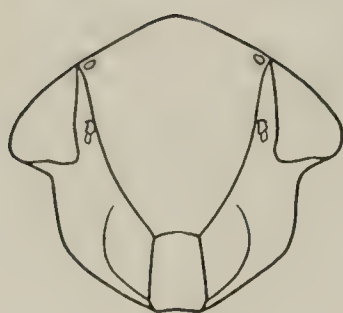
Fig. 226.—*Polyamia weedi*.

Fig. 227.—*Hebecephalus cruciatus*.

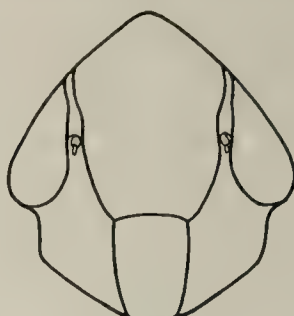
Fig. 228.—*Scaphoides immistus*.

Fig. 229.—*Norvellina seminuda*.

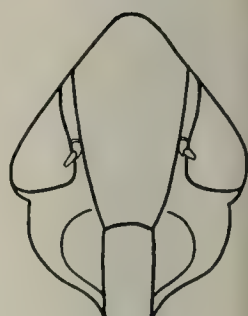
Fig. 230.—*Amplicephalus osborni*.



231A



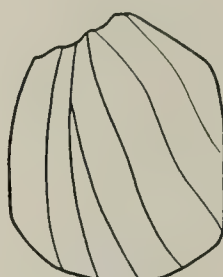
232A



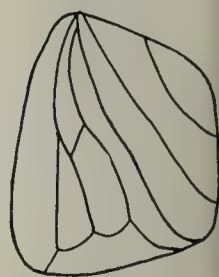
233A



234B



237C



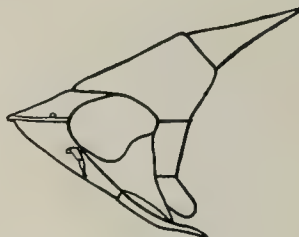
238C



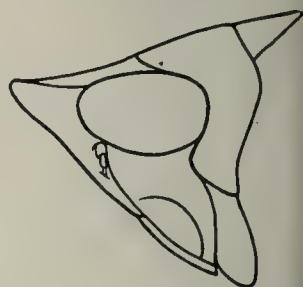
235B



236B



239D



240D

Athysaninae. A, face; B, seventh sternite of female; C, elytron; D, lateral aspect of head and thorax.

Fig. 231.—*Paraphlepsius optatus*.

Fig. 232.—*Flexamia inflata*.

Fig. 233.—*Gillettiella atropuncta*.

Fig. 234.—*Colladonus clitellarius*.

Fig. 235.—*Idiodonus kennicotti*.

Fig. 236.—*Psammotettix striatus*.

Fig. 237.—*Athysanella acuticauda*.

Fig. 238.—*Lonatura catalina*.

Fig. 239.—*Fieberiella florii*.

Fig. 240.—*Doratura stylata*.

11. Lateral margins of pronotum very short, eyes extending back almost to base of elytra, fig. 202. **84. Tropicatus**
- Lateral margins of pronotum longer, eyes distinctly separated from base of elytra, figs. 422, 423. **85. Paraphlepsius**
12. Vertex with two large black spots on margin. Male plates, fig. 242, deeply notched on outer margins. **79. Orientus**
- Vertex without marginal spots; male plates not notched on outer margins. 13

13. Head about three-fourths as wide as pronotum. Anterolateral margin of pronotum strongly sloping to eyes. Elytra decidedly elongate. Male pygofers each with a pronounced rounded apical lobe. Female seventh sternite truncate, with a median narrow incision, figs. 429-432. **87. Iowanus**
- Head only slightly narrower than pronotum; anterolateral margin of pronotum less sloping to eyes, as in fig. 422. Elytra rather short and broad. Male pygofers without apical rounded lobes,

fig. 428. Female seventh sternite excavated or broadly notched, fig. 428.

86. *Texananus*

14. Claval veins of each elytron obliquely angled with commissural margin, as in fig. 423. 22

Claval veins of each elytron bent so as to meet commissural margin at right angle, fig. 215. 15

15. Elytron with supernumerary veinlets along claval suture, fig. 215. 44. *Prescottia*
Elytron without supernumerary veinlets along claval suture, fig. 228. 16

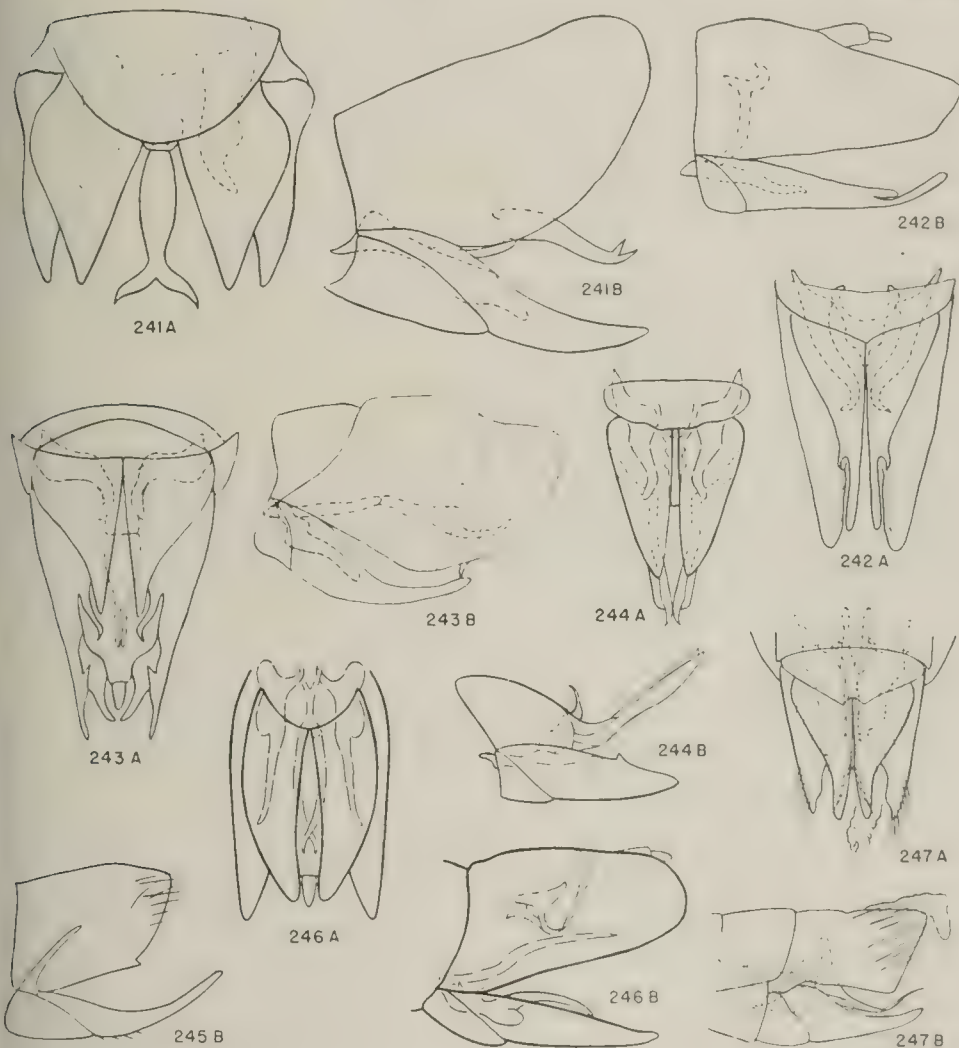
16. Male plates long and attenuated, figs. 280-286; one or two veinlets arising from outer anteapical cell and reaching costal margin.

43. *Osbornellus*

Male plates variable, not attenuated; two to four veinlets arising from outer anteapical cell, fig. 228. 17

17. Male plates, fig. 246, gradually tapered to bluntly pointed apices, almost as long as pygofers, and reaching to tip of anal tube

42. *Lonenus*



Athysaninae male genitalia. A, ventral aspect; B, lateral aspect.

Fig. 241.—*Scaphytopius elegans*.

Fig. 242.—*Orientus ishidae*.

Fig. 243.—*Fieberiella florii*.

Fig. 244.—*Paluda mella*.

Fig. 245.—*Macrosteles divinus*. (Redrawn after Dorst.)

Fig. 246.—*Lonenus intricatus*.

Fig. 247.—*Doleranus vividus*.

- Male plates, figs. 248-279, much shorter, not reaching anal tube. **41. Scaphoideus**
18. Vertex very narrow and conical, one and one-third times as long as width between eyes, fig. 210; antennal fossa touching eye, fig. 233*A*. **66. Gillettiella**
Vertex equal to or less than width between eyes, as in fig. 209. 19
19. Anterior margin of vertex sharply angled with front, the apex slightly turned up, fig. 240*D*. **69. Doratura**
Anterior margin of vertex bluntly angled or rounded to front. 20
20. Wing veins usually indistinct. 21
Five distinct veins, an outer one forked near middle, fig. 237*C*. **71. Athysanella**
21. Color uniformly straw yellow; antennal fossa touching eye or extremely close, as in fig. 233*A*; vertex conical, fig. 203. **56. Lonatura**
Body black or bicolored; antennal fossa separated from eye by at least half its width; vertex evenly rounded, fig. 403. **70. Driotura**
22. Dark straw colored above, the entire dorsum covered with many very small brown dots; outer anteapical cell, fig. 223, divided, with one to three crossveins reaching costal margin from anterior cell; front margin of vertex thin and sharply angulate, fig. 239*D*. **88. Fieberiella**
Color variable but without small brown dots; outer anteapical cell usually entire, as in fig. 218. 23
23. Four or more crossveins reaching costal margin from outer anteapical cell and outer branch of the first sector, figs. 214, 295. 24
Two crossveins reaching costal margin from outer anteapical cell and none from outer branch of first sector, as in fig. 218. 27
24. Margin of vertex acutely angled with front. 25
Margin of vertex obtusely angled with front. 26
25. Vertex narrowly and transversely depressed behind anterior margin; numerous crossveins on discs of elytra next to each claval vein, fig. 295. **80. Mesamia**
Disc of vertex flat, slightly depressed but not narrowed behind margin, fig. 298; elytra without crossveins next to each claval vein. **46. Platymetopius**
26. Costal veins conspicuously expanded on margin, fig. 219. **78. Menosoma**
Costal veins even in width, scarcely at all expanded on margin, fig. 214. **81. Aligia**
27. Vertex nearly acutely angled with front and with a slight transverse depression behind apex. 28
Vertex more bluntly angled with front and without depression behind apex. 29
28. Vertex finely and longitudinally striate; pronotum finely and transversely striate. **91. Eutettix**
Vertex and pronotum smooth and without striae. **90. Bandara**
29. Side of pronotum behind eye extremely narrow, fig. 207. **94. Atanus**
Side of pronotum behind eye at least as wide as posterior tibia at base, fig. 204. 30
30. Width of vertex more than twice its median length, fig. 204, and generally more rounded to front. 31
Width of vertex not more than twice its median length, fig. 463, and generally more flattened and angulate with front. 33
31. Color generally uniformly green or straw yellow, and not sharply contrasting on dorsum or with dark spots on vertex. **92. Chlorotettix**
Colors usually sharply contrasting, or nearly uniformly dark brown, with dark spots on vertex. 32
32. Female seventh sternite, fig. 234*B*, excavated, with a long spatulate process at middle of excavation; elytra dark brown, with a yellow saddle spot on each clavus, fig. 465 (Illinois species). **99. Colladonus**
Female seventh sternite, fig. 235*B*, produced on posterior margin and with a slight median incision; elytra variously colored. **98. Idiodonus**
33. Anterior margin of vertex with black spots or bands, figs. 462, 463. **96. Cicadula**
Margin of vertex without black spots or bands. 34
34. Male plates, fig. 244, each with dorsal blunt spine on apical half; each pygofer terminating in a bladelike process as long as basal portion. **97. Paluda**
Male plates each without dorsal spine, as in fig. 247; each pygofer rounded or angled. 35
35. Seventh sternite of female deeply and sinuately emarginate; outer margin of male plate, fig. 247, sinuate before apex. **93. Doleranus**
Seventh sternite of female slightly emarginate or a little produced; outer margin of male plate, fig. 461, evenly curved to apex. **95. Elymana**
36. At least pronotum and elytra entirely black; outline of veins indistinct on discs of elytra. 37
Pronotum and elytra not entirely black; outline of veins usually distinct. 38
37. Vertex bluntly angled; head wider than pronotum, fig. 409. **74. Ophiola**
Vertex almost evenly rounded; head and pronotum subequal in width, fig. 403. **70. Driotura**
38. Color pale green, with a large isolated dark spot in middle of each elytron. **51. Flexamia**
Color variable and without isolated black spot. 39
39. Elytra with a large irregular brown X-shaped mark, the lower arms joined on suture by an irregular band. **45. Sanctanus**

- Elytra without X-shaped mark. 40
40. Elytra milky white, with three complete brown to black cross bands, one at base, a median band, and a subapical one, fig. 225. 64. *Unoka*
Elytra with not more than two cross bands. 41
41. Pronotum with four or six longitudinal dark stripes, the median pair continued on the pronotum, as in fig. 401. 42
Pronotum without stripes continued on pronotum. 43
42. Vertex longer than wide and with two longitudinal stripes anterior to median pronotal pair, fig. 327. 51. *Flexamia*
Vertex wider than long, with two rounded spots anterior to median pair of pronotal stripes, figs. 392, 394. 68. *Commellus*
43. Dorsum with a single broken longitudinal dark band extending from apex of vertex to apex of clavus; entire end of each elytron with wide appendix. 51. *Flexamia*
Dorsum without a single median band; each elytron with appendix variable. 44
44. Inner sector of each elytron not forked and with only two anteapical cells, fig. 213. 68
Inner sector of each elytron twice forked, forming three anteapical cells, as in fig. 227. 45
45. Elytra each with two or more crossveins between first and second sectors, as in fig. 224. 46
Elytra each with not more than one crossvein between first and second sectors, as in fig. 216. 59
46. Vertex fully twice as long as wide and depressed on each side of apex below margin, fig. 205. 50. *Acurhinus*
Vertex much less than twice as long as wide and convex on each side of apex below margin. 47
47. Usually four to eight crossveins on each clavus, as in fig. 226. 48
Usually not more than one to three crossveins on each clavus. 49
48. Length usually exceeding 4 mm.; vertex about one and one-half times as wide as long, fig. 208. 60. *Amplicephalus*
Length usually less than 3 mm.; median length of vertex and width subequal. 54. *Polyamia*
49. Central anteapical cell divided, fig. 220; apical cells sometimes very short. 50
Central anteapical cell not divided, fig. 224; apical cells usually longer. 52
50. Inner apical cell of each elytron with a dark spot inside the posterior angle, fig. 221. 53. *Palus*
Inner apical cell of each elytron without a spot inside posterior angle, although veins may be marked with fuscous, fig. 220. 51
51. Length usually 4 mm. or more; disc of vertex flat or even slightly depressed. 61. *Arundanus*
Length usually less than 3 mm.; disc of vertex convex. 55. *Deltocephalus*
52. Costal region of each elytron with strongly reflexed veins arising from outer anteapical cell and reaching costal margin, fig. 224; head with a small depression behind apex. 51. *Flexamia*
Costal veins usually at most only slightly angulate forward from outer anteapical cell, fig. 221; head without depression behind apex, although it may be somewhat flattened between eyes. 53
53. Color above uniformly straw yellow, orange, or brown, and without markings, fig. 203. 56. *Lonatura*
Color variable but always with additional markings on head, pronotum, or elytra. 54
54. Inner apical cell of each elytron with a distinct dark spot inside posterior angle, fig. 221; vertex usually with a pair of longitudinal broken stripes, figs. 345-347; usually a dark spot on margin of elytron in front of costal veinlets. 53. *Palus*
Without dark spot inside posterior angle of inner apical cell, although cell often margined with fuscous; head may be marked but without longitudinal stripes. 55
55. Appendix of each elytron very narrow and extending only slightly beyond posterior angle of inner apical cell, fig. 222; elytra usually broader at or near apex of each clavus. 52. *Latulus*
Appendix of each elytron broader and extending at least to middle of apical cell, as in fig. 227; elytra usually more slender and not broader near apex of each clavus. 56
56. Veins of elytra, especially in apical region and on each clavus, heavily and nearly uniformly margined with black or brown, fig. 227. 57. *Hebecephalus*
Veins of elytra unmargined with black or brown, or only irregularly so. 57
57. Vertex bluntly angled and slightly convex, fig. 368. 55. *Deltocephalus*
Vertex generally more acutely angled, and flat or even a little depressed. 58
58. Male plates, figs. 378-385, decidedly larger than valve; female seventh sternite, fig. 386, notched, produced, or with teeth, not simple on posterior margin. 58. *Laevicephalus*
Male plates, figs. 387, 388, short, smaller than valve; female seventh sternite, fig. 236B, usually broadly and concavely rounded. 59. *Psammotettix*
59. Appendix of each elytron extending broadly around entire apex, fig. 216. 72. *Exitianus*
Appendix, if present, not extending beyond middle of apex of elytron, as in fig. 230. 60
60. Vertex short and broad, very little longer at middle than next to eyes, and less than one-half its width between eyes, fig. 206. 61
Vertex angulate, conspicuously longer at middle than next to eyes, and equal to or more than one-half its width between eyes, fig. 399. 62
61. Color bright green; elytra with white areolar spots; vertex unmarked. 75. *Opsius*

- Color more yellowish or dull green to brown; vertex with a transverse brown band, fig. 206. **76. Limotettix**
62. Vertex longer than or equal in length to width between eyes, as in fig. 395. **63**
Vertex distinctly shorter than width between eyes, as in fig. 397. **64**
63. At least some of apical wing veins brown; head equal in width to or slightly narrower than pronotum, figs. 395, 396. **67. Stirellus**
Veins uniformly yellow or greenish; head distinctly wider than pronotum. **65. Unerus**
64. Pronotum with a very distinct shiny black transverse band on basal half behind head, fig. 397. **63. Amblysellus**
Pronotum without distinct band, although often with faint to distinct transverse lines. **65**
65. Color above uniformly pale green; vertex with four black spots, in addition to dark ocelli, close to front margin, fig. 391. **62. Graminella**
Color usually some shade of brown or straw yellow and sometimes with faint to distinct transverse bands or lines on vertex. **66**
66. Vertex uniformly yellowish and with a narrow dark band behind front margin reaching from eye to eye, fig. 208. **60. Amplicephalus**
Vertex marked or unmarked but without narrow band behind front margin. **67**
67. Vertex and pronotum with irregular or sinuate transverse black to dark brown lines, fig. 409. **74. Ophiola**
Vertex and pronotum sometimes obscurely marked with darker spots but without transverse lines. **68**
68. Vertex distinctly angled and twice as long at middle as length next to eyes, fig. 209; body slender, more than three times as long as wide; elytra covering abdomen. **77. Thamnotettix**
Vertex more bluntly angled and at middle, not more than one and three-fourths times length next to eyes, fig. 405; body usually broad, less than three times as long as wide; elytra often short, exposing apex of abdomen. **73. Euscelis**
69. Vertex sharply angulate and much longer than width between eyes; each eye longer than distance between eyes, fig. 210; appendix of each elytron extending completely around apex. **66. Gillettiella**
Vertex usually more bluntly angulate to evenly rounded and never more than width between eyes, as in figs. 466, 472; appendix of each elytron not reaching beyond apical cell. **70**
70. Vertex longer at middle than next to eyes, figs. 472-477. **71**
Vertex almost parallel margined, figs. 466-468. **100. Davisonia**
71. Ovipositor greatly extending beyond pygofer; each male pygofer without notch or process on posterior margin. **71. Athysanella**
Ovipositor extending only to apex of each pygofer; male pygofer with notch or process on posterior margin, as in fig. 245B. **72**
72. Each male pygofer faintly notched on posterior margin. **101. Sonronius**
Each male pygofer with a small finger-like process on posterior margin, fig. 245B. **102. Macrosteles**

41. SCAPHOIDEUS Uhler

Scaphoideus Uhler (1889, p. 33).

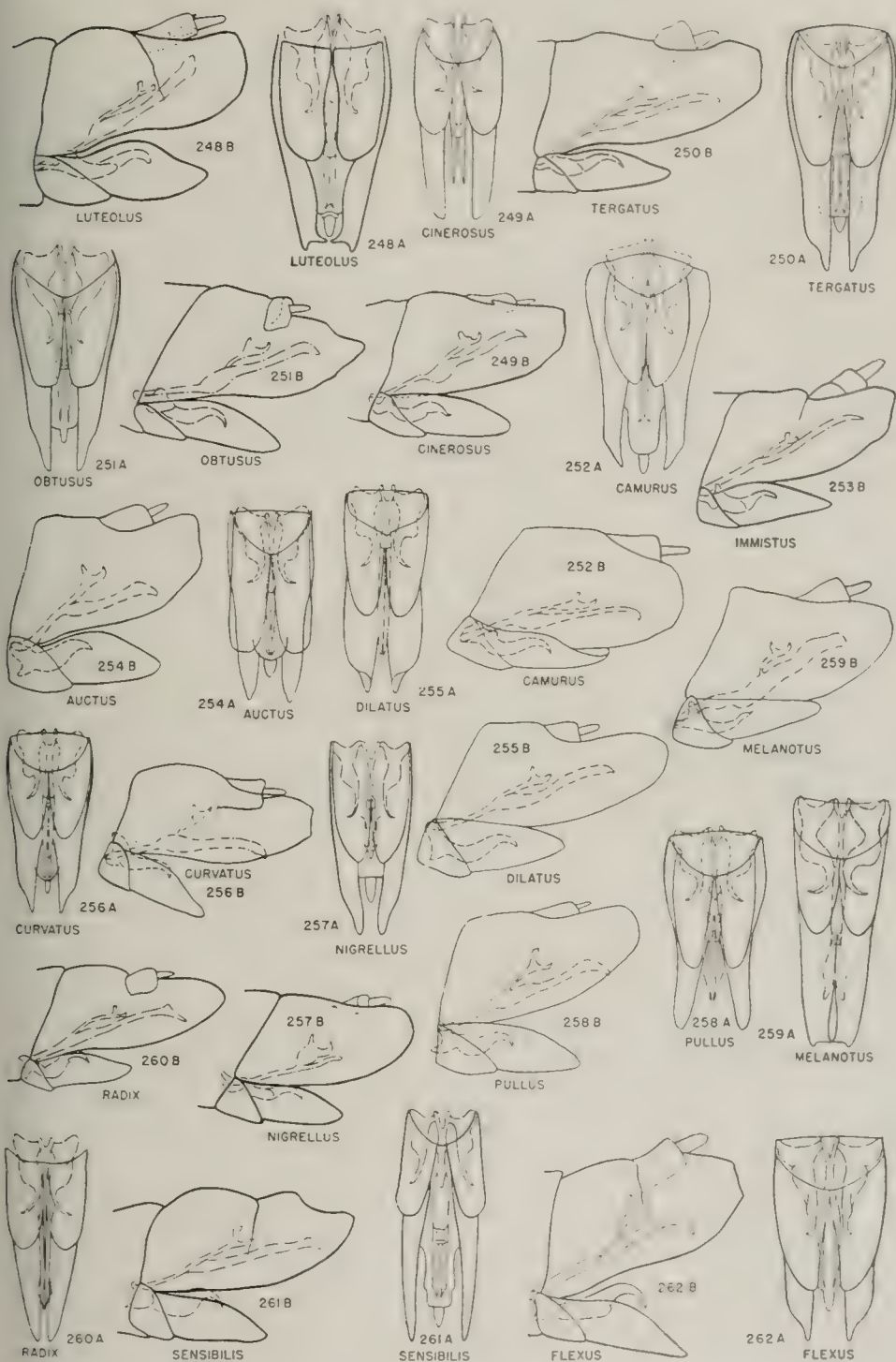
Fig. 228. Vertex produced, triangular, flat above, bluntly angled. Outer anteapical cell of each elytron oblique, the basal portion of which bears two or three oblique veinlets to costa. Practically all the species of the genus have rather conspicuous color markings. The commissural line is usually marked with a white stripe, which is variously broken by dark coloration and in most species forms a specific recognition color pattern.

Insofar as records go, the species of the genus seem to occur frequently upon rank growing herbaceous vegetation, such as *Solidago* and *Aster*, especially in open woodland and similar habitats.

DeLong (1939a) reviewed the species of *Scaphoideus* and recorded 46 species as occurring in the United States. Nearly all of these are found in the eastern United States, and 31 species are known from Illinois.

KEY TO SPECIES

1. Males. 2
Females. 33
2. Usually small, narrow, length not exceeding 6 mm. Plates only slightly narrowed apically, apexes broadly rounded, as in fig. 248. 3
Usually larger, robust, length over 6 mm. Plates broad at bases, gradually narrowed to inner margins, apexes bluntly or sharply angled, as in fig. 271. 21
3. Dorsal process of aedeagus in lateral view with a long slender basal portion, bifurcate at apex, as in fig. 250; ventral portion usually much longer than dorsal. 4
Dorsal process of aedeagus shorter, more inflated or bulbous, usually with a pair of small terminal processes, as in fig. 257; ventral portion shorter than or only slightly exceeding dorsal process. 17
4. Claval areas of elytra brown, almost unicolorous, without spots or pale areas, veins inconspicuous. 5
Claval areas of elytra spotted or with pale areas, veins conspicuous. 6
5. Aedeagus, fig. 248, in lateral view broadened at apex and directed dorsally. 31. **luteolus**
Aedeagus, fig. 250, narrower, pointed at



Figs. 248-262.—*Scaphoideus*, male genitalia; both internal and external structures shown. A, ventral aspect; B, lateral aspect.

- apex and curved slightly ventrally.... **1. tergatus**
6. Elytra transversely banded, milky white, faintly marked with brown almost to apex of each clavus; dark brownish band across apex of clavus; apices of elytra smoky.... **29. obtusus**
Elytra not distinctly banded, entirely pale or mottled.....7
7. Elytra pale in color, veins dark; dorsal portion of aedeagus, fig. 249, with a median tooth between anterior and posterior terminal processes; ventral portion of aedeagus in lateral view broadened on apical half, apex curved ventrally and pointed..... **23. cinerosus**
Elytra dark in color or with dark markings; dorsal portion of aedeagus without median apical tooth.....8
8. Ventral process of aedeagus narrow, tapered at apex, as in fig. 252.....9
Ventral process of aedeagus broader, or enlarged at apex, or both, as in fig. 254.....10
9. Ventral aedeagus process, fig. 253, narrow throughout its length, apex gently curved ventrally..... **27. immistus**
Ventral aedeagus process, fig. 252, enlarged at base of dorsal process, tapered to slender apex, which is strongly curved ventrally..... **7. camurus**
10. Face pale in color, often marked with dark arcs above.....11
Face black or smoky, bordered with brown or black, dark arcs sometimes concealed by coloration, or arcs pale.....13
11. Aedeagus, fig. 254, enlarged just before bluntly pointed apex..... **11. auctus**
Male aedeagus not enlarged at apex, as in fig. 255.....12
12. Pygofer truncate at apices; aedeagus, fig. 256, slightly curved downwardly at apex..... **6. curvatus**
Pygofer rounded at apices; aedeagus, fig. 255, one-fourth longer, more narrowed at apex..... **5. dilatus**
13. Face entirely black, except for a small white spot just below apex, arcs absent..... **24. melanotus**
Face smoky to brown, with conspicuous arcs on upper portion.....14
14. Elytra rather uniformly dark in color; scutellum conspicuously pale, dark only in basal angles.....15
Elytra with numerous pale markings or areas; scutellum with dark markings other than on basal angles.....16
15. Aedeagus, fig. 258, with ventral portion enlarged at junction of dorsal process and again at apex, the latter curved ventrally and bluntly pointed..... **10. pullus**
Ventral portion of aedeagus, fig. 261, almost uniform in size throughout, slightly narrowed on upper surface just before apex, which is obliquely sloping to ventral blunt apex..... **28. sensibilis**
16. Pygofer blunt, broadly rounded; ventral portion of aedeagus, fig. 262, almost uniform in size throughout, apical portion curved ventrally, apex truncate, with a pointed ventral projection..... **8. flexus**
Pygofer more elongate, bluntly pointed; ventral portion of aedeagus, fig. 260, narrowed on median half, apex obliquely sloping, with a pointed tooth on upper margin and an elongate, more acutely pointed ventral apex..... **9. radix**
17. Face black or dark brown, with pale arcs beneath margin of vertex; dorsal portion of aedeagus, fig. 257, constricted just before divergent apical processes..... **14. nigrellus**
Face pale, often conspicuously yellow and with dark arcs.....18
18. Entire dorsal surface pale; veins dark, a few dark markings on elytra; apices of elytra brown or smoky.... **30. opalinus**
Darker in color, brownish or heavily marked with brown.....19
19. Vertex and scutellum conspicuously light, faintly marked; elytra dark brown to black, white commissural spot on each elytron conspicuous; ventral portion of aedeagus, fig. 264, very short..... **4. scelestus**
Vertex and scutellum darker or more heavily marked; commissural spot on each elytron not conspicuously white; ventral portion of aedeagus longer, as in fig. 275.....20
20. Ventral aedeagus process, fig. 275, not as long as dorsal process; apex of each pygofer rounded..... **25. littoralis**
Ventral aedeagus process, fig. 265, longer than dorsal process; apex of each pygofer more pointed..... **13. diutius**
21. Orange yellow or orange red in color....22
Some shade of brown, marked with dark brown or black.....23
22. Length not over 5 mm.; vertex almost uniform orange yellow, without median transverse band; margin of vertex white, with a black marginal line above and another below..... **12. baculus**
Length more than 6 mm.; vertex white to yellow, with an orange transverse band..... **33. ochraceous**
23. Pygofer unusually long, narrowed, and rather sharply pointed apically, as in fig. 273.....24
Pygofer normally produced, rounded, or truncated.....25
24. Aedeagus, fig. 276, in ventral view with broad processes that bear large chelate-like structures at apices..... **18. chelus**
Aedeagus, fig. 273, in ventral view with processes that taper to form long slender apically curved structures that cross each other..... **16. elongatus**
25. Aedeagus, fig. 270, in lateral view with basal portion decidedly wider than apical portion..... **2. frisoni**
Aedeagus in lateral view with basal portion not wider than apical portion....26
26. Apical processes of male aedeagus, fig. 267, in ventral view appearing flat, about the same width throughout, evenly curved, rather abruptly narrowed to pointed apices..... **3. merus**
Apical processes of male aedeagus in ventral view unevenly curved or gradu-

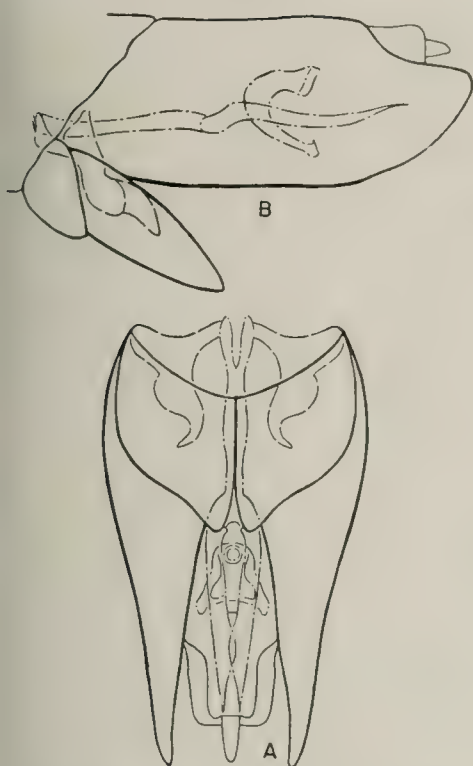
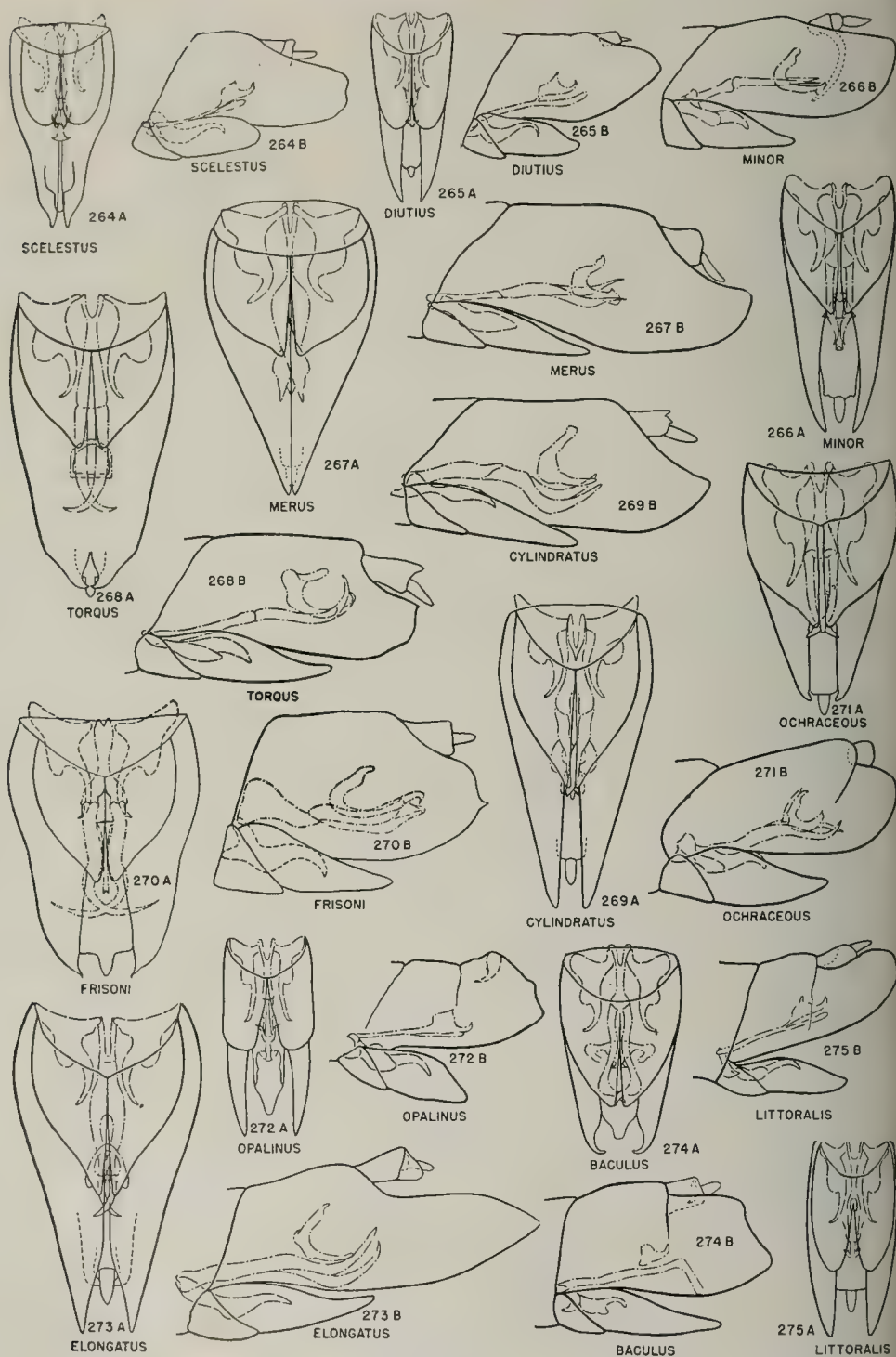


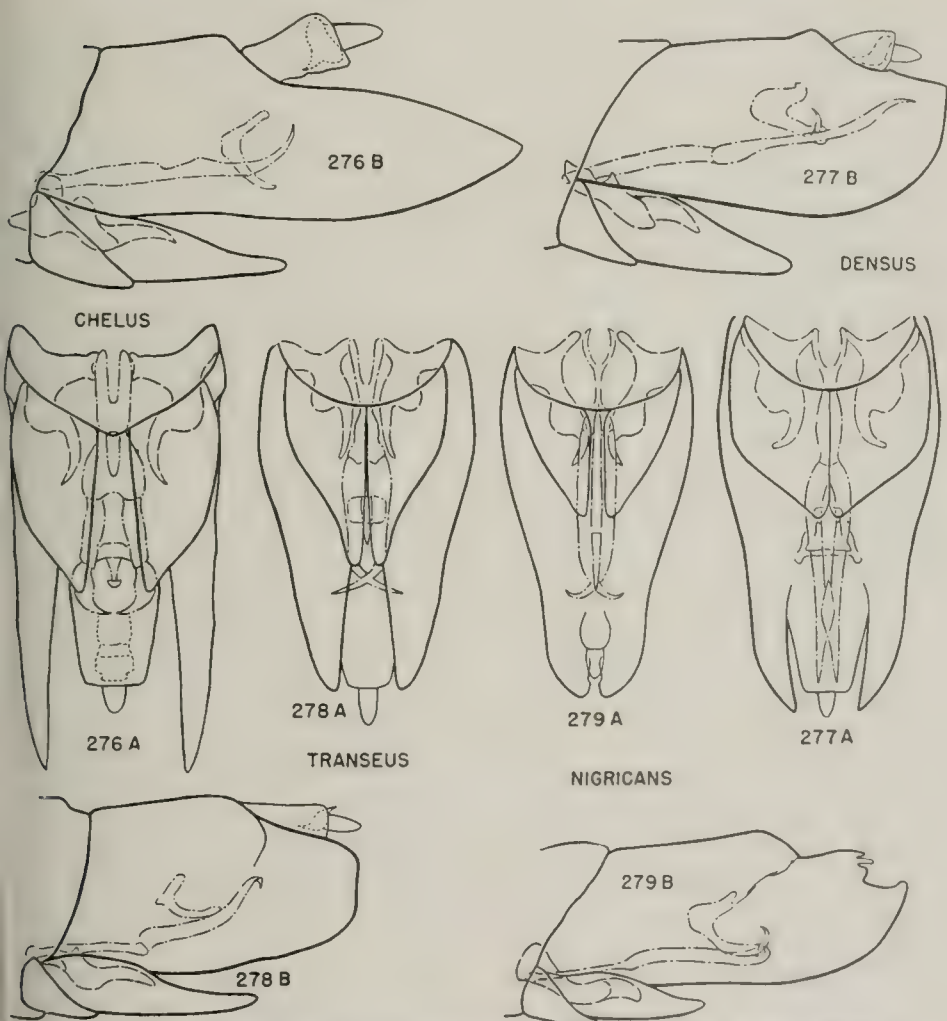
Fig. 263.—*Scaphoideus major*. A, ventral aspect, and, B, lateral aspect of male genitalia, both internal and external structures.

- ally tapered to more acutely pointed apices 27
27. Apexes of ventral processes of aedeagus in ventral view long, slender, crossing each other, tips directed laterally, as in fig. 279 28
- Apexes of ventral processes of aedeagus usually blunt, or if acutely pointed they are directed caudad and not crossed at apices, as in fig. 269 30
28. Vertex bluntly angled, almost rounded, heavily marked with black; transverse bands of vertex black 22. **nigricans**
- Vertex more strongly produced, marked with brown; transverse band on vertex some shade of red or orange 29
29. Aedeagus, fig. 278, widened near base in ventral view, gradually tapering to long slender apex 19. **transeus**
- Basal two-thirds of aedeagus, fig. 268, about the same width in ventral view, apical third gradually tapering 15. **torqus**
30. Aedeagus, fig. 269, with ventral processes in ventral aspect unevenly curved, apices bluntly pointed; male plates long and narrow 17. **cylindratus**
- Ventral processes of aedeagus rather evenly curved, apices acutely pointed; male plates shorter and broader, as in fig. 266 31
31. Ventral processes of aedeagus enlarged on inner margins about one-third the distance from their apices, outer margins straight, as in fig. 277 32
- Ventral processes of aedeagus, fig. 266, not enlarged between base and apex, apical fourth gradually narrowed and curved slightly inwardly to sharply pointed appressed apices 32. **minor**
32. Ventral portion of aedeagus, fig. 277, one-half longer than connectives; dorsal aedeagus process broad at base and with short thick apical portion, which is rounded at apex and bears a conspicuous dorsal spine 20. **densus**
- Ventral portion of aedeagus, fig. 263, only slightly longer than connectives; dorsal aedeagus process semicircular and tapered to apex, which is blunt, slightly enlarged, and bears a small dorsal spine 21. **major**
33. Vertex orange or with a bright orange transverse band 34
- Vertex brown or marked with brown 35
34. Face and vertex almost uniform orange 12. **baculus**
- Vertex pale, with a bright orange transverse band; pronotum and scutellum mottled with orange 33. **ochraceous**
35. Elytra appearing banded, each with anterior portion almost to tip of clavus white, posterior portion dark brown 29. **obtusus**
- Elytra not appearing banded 36
36. Elytra almost plain brown in color, each with a few pale markings 37
- Elytra light in color, or each with numerous pale markings 38
37. Elytra uniform brown, without dark markings 31. **luteolus**
- Elytra brown, each with a few dark markings on clavus 1. **tergatus**
38. General appearance light gray or white, with few dark markings 39
- General appearance brown, mottled with white 40
39. White, with dark veins and a few dark spots on elytra 23. **cinerosus**
- White, elytra without dark veins and with a few pale spots 30. **opalinus**
40. Face usually dark brown to black 41
- Face usually pale, light brown, or dusky 43
41. Vertex sharply pointed, heavily marked with black, and with a broad black band 14. **nigrellus**
- Vertex more bluntly angled, marked with brown; transverse band brown or tawny 42
42. Transverse band of vertex broad, brown in color 6. **curvatus**
- Transverse band narrow, pale tawny in color 24. **melanotus**
43. Transverse band on vertex usually narrow 44
- Transverse band on vertex usually broad, often involving posterior half of vertex 49
44. Face pale yellow; vertex, pronotum, and scutellum pale; narrow pale band on vertex 4. **scelestus**



Figs. 264-275.—*Scaphoideus*, male genitalia; both internal and external structures shown. A, ventral aspect; B, lateral aspect.

- Face usually pale brown or dusky; pronotum or posterior portion of pronotum brown.....45
45. Length not more than 5.5 mm.....46
- Length usually 6.0 mm. or more.....48
46. Anterior half of pronotum usually pale; band on vertex tawny, appearing to lack a middle toothlike marking.....**10. pullus**
- Pronotum usually brown; vertex band with a central toothlike marking.....47
47. Vertex band brown.....**9. radix**
- Vertex band tawny.....**11. auctus**
48. Vertex short, almost rounded at apex, conspicuously marked with black.....**22. nigricans**
- Vertex bluntly angled at apex.....**17. cylindratus**, **18. chelus**
49. Length 6.5 to 7.0 mm.; female seventh sternite produced and angled at middle, lateral angles absent....**26. productus**
- Length smaller, or with lateral angles conspicuous.....50
50. Marginal black line above apex of vertex heavy, usually broken at middle and intensified either side of break; line often reduced to spots.....51
- Marginal line usually narrower, continuous at margin, not heavier at apex...54
51. Length less than 6 mm.....52
- Length 6 mm. or more.....53
52. Basal half of vertex usually brown; elytra heavily marked with brown.....**32. minor**
- Basal half of vertex usually pale; elytra with lighter brown markings.....**19. transeus**
53. Vertex sharp pointed, ends of broken marginal line usually reduced to spots at apex.....**15. torqus**
- Vertex more bluntly angled, ends of broken marginal line usually reduced to spots



Figs. 276-279.—*Scaphoideus*, male genitalia. *A*, ventral aspect; *B*, lateral aspect.

- which often merge with projecting tooth on transverse band
- 21. *major*, 3. *merus*, 2. *frisoni*, 20. *densus*, 16. *elongatus*
54. Length not over 5.5 mm. 55
- Length 5.5 mm. or more
- 5. *dilatatus*, 7. *camurus*, 28. *sensibilis*
55. Toothlike mark on transverse band minute
- 13. *diutius*, 27. *immistus*
- Toothlike mark on transverse band larger
- 8. *flexus*, 25. *littoralis*

1. *Scaphoideus tergatus* DeLong

Scaphoideus tergatus DeLong (1939a, p. 45).

Length 5.5–6.0 mm. Similar to *luteolus*, but elytra more spotted with pale areas. Vertex white, with a very narrow marginal line, slightly interrupted at middle, and with a broad testaceous transverse band between anterior margins of eyes; band scarcely produced at middle. Pronotum testaceous, with a white transverse band on middle. Each elytron dark brown, with a few pale areas; veins on clavus indistinct, veins on corium and costa brown, apical portion black.

Female seventh sternite with apical third of posterior margin produced in a short broad rounded black tooth. Male aedeagus, fig. 250, in lateral view with ventral portion narrow, widened at junction of dorsal portion; apex gradually narrowed to pointed tip, which is slightly curved ventrally.

This species is known only from Illinois. A few specimens were taken in low flood-plain woods in a very moist habitat.

Illinois Records.—JONESBORO: state forest, July 31, 1934, DeLong and Mohr, 1 ♂, 1 ♀. HAVANA: Aug. 30, 1917, 1 ♀.

2. *Scaphoideus frisoni* DeLong & Mohr

Scaphoideus frisoni DeLong & Mohr (1936, p. 975).

Length 6 mm. Vertex white, with dark line above front margin interrupted at middle and widened either side of apex. Transverse fuscous band with central portion produced, ends sloping anteriorly. Scutellum pale, basal angles darker. Elytra white, mottled with brown, veins and apex of each dark brown.

Female seventh sternite broadly and roundedly produced and slightly keeled at middle. Male plates about as long as combined basal width, convexly rounded on basal portion, concavely rounded to form blunt pointed apices. Aedeagus, fig. 270, with a pair of long processes arising near

base, in ventral view separated near base, almost contiguous near middle, then again separated and crossing each other so that the apical fourth of each is directed laterally and is slender and tapered at apex. A broad dorsal tooth on apex of each pygopher.

This species was found on herbaceous plants in woodland areas in northern Illinois. Its distribution in the United States is decidedly northern.

Illinois Records.—ANTIOCH: Aug. 24, 1935, DeLong & Ross, 1 ♀. PALOS PARK: Aug. 8, 1935, DeLong & Ross, 1 ♀.

3. *Scaphoideus merus* DeLong & Beery

Scaphoideus merus DeLong & Beery (1936, p. 336).

Length 6.5–7.0 mm. Resembling *carinatus* Osborn (1900a, p. 201) in size and general appearance but with distinctive male genitalia. Vertex strongly produced, apex bluntly angled, almost as long at middle as basal width between the eyes. Face pale, with two heavy dark bands below margin of vertex. Marginal line above vertex broken at middle and widened on either side of apex; median transverse band on vertex decidedly notched either side of central anterior produced portion, causing it to appear trilobate anteriorly. Pronotum and scutellum dark brown, mottled. Elytra white, washed with pale brown; veins, margins at apices, and a spot on center of each clavus dark brown.

Female seventh sternite with prominent lateral angles, posterior margin black, almost truncate, slightly emarginate either side of middle. Male plates short and broad, length equaling combined basal width, convexly rounded to form blunt apices. Styles, fig. 267, abruptly narrowed at two-thirds their length to form narrow processes that are bent strongly outward and produced. Aedeagus in ventral view with a pair of short broad flat processes arising near the base, curved so as to leave an opening between them at base, but overlapping at apices; dorsal process with the apical portion rather broad, rounded at apex, and with a dorsal pointed tooth.

This species has previously been recorded from the District of Columbia and Pennsylvania only.

Illinois Records.—JUSTICE: in woods, July 23, 1937, Mohr & Burks, 2 ♂. SEY-

MOUR: in woods, July 7, 1937, Mohr & Burks, 1 ♂. VOLO: in bog, Aug. 22, 1937, Burks & Ross, 1 ♂.

4. *Scaphoideus scelestus* DeLong & Mohr

Scaphoideus scelestus DeLong & Mohr (1936, p. 974).

Length 5-6 mm. Superficially resembling *melanotus* in color. Face pale, with two complete dark lines and broken arcs on upper portion. Vertex, pronotum, and scutellum usually pale in color, transverse band between eyes narrow and pale. Elytra heavily infuscated with dark brown or black, anterior half of each appearing uniformly black without areoles; two milky white areoles on middle of each clavus, and a few in anteapical cells.

Female seventh sternite roundedly produced and black margined. Male plates broadly rounded at apices. Aedeagus, fig. 264, in lateral view with basal portion slender and straight; dorsal process arising near apex, with a point at base; apex with a long dorsally curved finger-like process on caudoapical extremity.

This species has been taken in small numbers from herbaceous vegetation in Illinois. It was described from Pennsylvania.

Illinois Records.—METROPOLIS: Aug 16, 1891, Hart 1 ♂; Aug. 17, 1891, Shiga & Hart, 1 ♂.

5. *Scaphoideus dilatus* DeLong & Mohr

Scaphoideus dilatus DeLong & Mohr (1936, p. 966).

Length 5.5-6.0 mm. Vertex pale, the transverse, orange-red band rather broad. Pronotum dark brown, scutellum paler. Elytra brownish, apices black, veins black; each clavus with two white very small areolar spots and three or four white spots in anteapical cells. Face pale brown, with one complete line below margin of vertex.

Female seventh sternite strongly and roundedly produced and broadly margined with black. Male plates with broadly rounded apices. Aedeagus in lateral view, fig. 255, gradually enlarged on apical third to a sharp pointed apex; dorsal process with two divergent processes at apex.

Described from Pennsylvania, this species is known from several localities in Illinois.

Illinois Records.—ANTIOCH: Aug. 24, 1935, DeLong & Ross, 5 ♀. MOMENCE: Aug.

22, 1934, DeLong & Ross, 1 ♂. VOLO: in bog, Aug. 24, 1935, DeLong & Ross, 3 ♂, 7 ♀. WHITE HEATH: June 4, 1939, J. C. Dirks, 2 ♂; July 31, 1939, J. C. Dirks, 2 specimens.

6. *Scaphoideus curvatus* DeLong & Mohr

Scaphoideus curvatus DeLong & Mohr (1936, p. 967).

Length 5 mm. Vertex yellowish, marginal line conspicuous; median dark reddish brown transverse band between eyes rather broad and produced at middle. Pronotum dark brown, with a pale transverse band. Apical half of scutellum pale yellow. Elytra brown; veins dark brown, with very pale areas; two very small areoles near center of each clavus along commissural line.

Female seventh sternite produced, rounded at apex, and black margined. Male plates broadly rounded at apices. Aedeagus in lateral view, fig. 256, narrowed at about half its length, then produced, and ventrally curved at apex, tip pointed; dorsal process arising from enlarged portion, broadened apically and bifurcate.

This species was described from specimens taken in southern Illinois.

Illinois Record.—NEW HAVEN, June 23, 1936, DeLong & Ross, 1 ♂, 1 ♀.

7. *Scaphoideus camurus* DeLong & Mohr

Scaphoideus camurus DeLong & Mohr (1936, p. 967).

Length 5.5-6.0 mm. Vertex white, with a rather narrow tawny band between eyes, band slightly produced at middle. Pronotum dark, with a pale transverse band behind eyes. Elytra pale brown, veins darker, intensity of dark markings variable, with dark markings usually on apical portions at least. Face yellow, with at least two complete dark lines below margin of vertex.

Female seventh sternite slightly rounded, produced, and black margined. Male plates broadly rounded apically. Aedeagus in lateral view, fig. 252, tapered toward apex, where it is sharply bent ventrally and pointed; dorsal process enlarged at apex; anterior apical process very small, almost wanting.

This species was described from Illinois and Pennsylvania. It has been taken in small numbers in low swampy wooded areas from herbaceous vegetation.

Illinois Record.—KARNAK: June 14, 1934, DeLong & Ross, 6 ♂.

8. *Scaphoideus flexus* DeLong & Mohr

Scaphoideus flexus DeLong & Mohr (1936, p. 968).

Length 5.0–5.5 mm. Vertex white, with a rather broad tawny band between the eyes, band scarcely produced anteriorly. Pronotum tawny, with paler transverse band on disc. Elytra brownish, marked with darker brown and with veins darker brown. Face tawny, with dark arcs on upper portion; narrow dark line just beneath margin of vertex, below which is a white band.

Female seventh sternite with prominent angles, posterior margin concavely and roundedly produced either side of a dark margined centrally produced lobe. Male plates with blunt rounded apices. Aedeagus in lateral view, fig. 262, with apical half gradually bending ventrally, apex enlarged, truncate, with a ventrally pointed tooth on ventral margin; dorsal process bifurcate at apex and concavely rounded between tips.

Recorded from Pennsylvania, Tennessee, and Illinois, *flexus* occurs on herbaceous vegetation in woodland areas.

Illinois Records.—Many males and females, taken June 14 to September 27, are from Apple River Canyon State Park, Ashley, Dolson, Dubois, Elizabethtown, Grafton, Herod, Jonesboro, Kampsville, Kankakee, Marshall, Rock Island, Shawneetown, Urbana, Vienna, Volo, and White Heath.

9. *Scaphoideus radix* DeLong & Mohr

Scaphoideus radix DeLong & Mohr (1936, p. 969).

Length 4.5–5.0 mm. Vertex pale, with a fine sinuate marginal line and a narrow conspicuous transverse band between anterior margins of eyes, band slightly produced at middle and bordered with reddish brown on its posterior margin. Pronotum dark brown, black behind either eye, a white cross band on anterior portion of disc. Elytra pale, mottled with brown, veins brown; each elytron with a large brown spot at apex of first claval vein and a large spot on disc. Face pale, dusky on either side next to eyes.

Female seventh sternite with posterior margin slightly concave on either side of a

central broadly produced lobe, which is blunt at apex and slightly bifid. Male plates with apices broadly rounded. Aedeagus, fig. 260, slender on apical half to near apex, which is enlarged into a foot-shaped structure with the long pointed toe portion extending ventrally; dorsal portion with bifurcate process.

Described from Illinois, this species was found only in open woodland in the southern portion of the state.

Illinois Records.—DIXON SPRINGS: July 9, 1935, DeLong & Ross, 1 ♀. ELIZABETHTOWN: May 22–24, 1932, Ross, Dozier, & Park, 1 ♀. HORSESHOE LAKE: on cypress, July 11, 1935, DeLong & Ross, 1 ♀. KARNAK: July 10, 1935, DeLong & Ross, 1 ♀.

10. *Scaphoideus pullus* DeLong & Mohr

Scaphoideus pullus DeLong & Mohr (1936, p. 969).

Length 4.5–5.5 mm. Vertex pale yellow, with a narrow black marginal line and a narrow transverse reddish band between eyes. Pronotum paler at middle, sides darker. Elytra pale brown, heavily infuscated, and with a few pale whitish arcs; each clavus appearing to have a much darker stripe along inner margin, with two paler spots on posterior half. Face pale brown, with arcs always conspicuous above.

Female seventh sternite produced and rounded. Male plates with broadly rounded apices. Aedeagus in lateral view, fig. 258, enlarged on apical fourth, curved ventrally near apex, the apex bluntly pointed on ventral side.

Known previously from the District of Columbia, Pennsylvania, and Wisconsin, this species is found also in several localities in the southern half of Illinois, and occurs in open woodland.

Illinois Records.—Males and females, collected June 9 to August 24, are from Dozier, Dubois, Eichorn, Golconda, Hardin, Karnak, Metropolis, Monticello, New Holland, and St. Joseph.

11. *Scaphoideus auctus* DeLong & Mohr

Scaphoideus auctus DeLong & Mohr (1936, p. 970).

Length 5 mm. Vertex pale, transverse band orange, a pale transverse band on anterior portion of pronotum and scutellum.

Elytra gray, heavily marked with dark brown or black, veins conspicuously dark. Face yellowish, with one complete dark line below margin of vertex.

Female seventh sternite strongly and roundedly produced, apex faintly notched. Male plates rounded at apexes. Aedeagus in lateral view, fig. 254, enlarged at apex and obliquely sloping to form a caudoventrally directed and bluntly pointed apex; dorsal process short and broad, the concave apex forming two short thick divergent processes.

This is a rather uncommon species and occurs in Illinois in woodland areas on herbaceous vegetation. It is also known from Wisconsin and Pennsylvania.

Illinois Records.—NEW HAVEN: June 23, 1936, DeLong & Ross, 1 ♂. URBANA: July 1, 1889, Marten, 1 ♂; June 27, 1889, Hart, 1 ♂; July 7, 1889, Hart 1 ♂.

12. *Scaphoideus baculus* DeLong & Mohr

Scaphoideus baculus DeLong & Mohr (1936, p. 970).

Length 4.5–5.0 mm. Tawny, almost devoid of white areolar spots. Face tawny, margin of vertex white, with a black marginal line above and two conspicuous black lines below. Vertex with tawny band so broad it covers surface almost entirely but leaves a narrow anterior pale area and a broad V-shaped posterior pale area. Pronotum usually darker than vertex, with traces of a white cross band just back of eyes. Elytra tawny, almost lacking white areolar spots, veins brown; each elytron with brown spots at apex, also at apex of first claval vein, and at apex of clavus.

Female seventh sternite with posterior margin concavely and roundedly produced to form a pair of prominent black teeth separated by a V-shaped notch. Male plates narrowed to inner margins, each bluntly angled. Aedeagus, fig. 274, with apical fourth bent sharply ventrally; apical portion sometimes uniform in width and sometimes tapered to apex.

The food plant of *baculus* is not known. This species has been collected in several Illinois areas. It has been recorded from Pennsylvania and Ohio, as well as Illinois.

Illinois Records.—ALTON: July 19, 1932, Ross & Dozier, 1 ♂. DOLSON: July 24, 1936, DeLong & Mohr, 1 ♂. DUBOIS:

sweeping along railroad, July 9, 1909, 1 ♀. URBANA: tree trunk, July 23, 1917, 1 ♂; tree trunk, Aug. 4, 1916, 1 ♀; Aug. 8, 1916, 1 ♀; Aug. 9, 1920, Malloch, 1 ♀; Aug. 12, 1935, Burks, 1 ♂; at light, Aug. 13, 1935, H. H. Ross, 1 ♂; tree trunk, Aug. 28, 1917, 7 ♂, 4 ♀; dredge ditch, Aug. 30, 1914, 1 ♀; forestry, Sept. 3, 1916, 1 ♀.

13. *Scaphoideus diutius* DeLong & Mohr

Scaphoideus diutius DeLong & Mohr (1936, p. 972).

Length 5 mm. Resembling *immistus* in color. Vertex pale, transverse band broad, tawny, scarcely produced at middle. Face yellow. Pronotum with a rather faint transverse band back of eyes. Elytra pale, tinged with brown, veins dark brown.

Female seventh sternite with posterior margin roundedly produced and black margined. Male plates with apexes broadly rounded. Aedeagus in lateral view, fig. 265, similar to that of *littoralis* but with the apical ventral processes longer than the dorsal process and the dorsal process with a more slender curved finger-like projection on posterior margin.

This species was taken in small numbers in the northern portion of Illinois in open woodland. It is known also from Pennsylvania.

Illinois Record.—STARVED ROCK STATE PARK: July 14, 1932, Dozier & Park, 2 ♂, 1 ♀.

14. *Scaphoideus nigrellus* DeLong & Mohr

Scaphoideus nigrellus DeLong & Mohr (1936, p. 973).

Length 4.5–5.0 mm. Black, resembling *sensibilis* in appearance. Vertex white, with a broad black transverse band between eyes, band strongly produced anteriorly and shading to brown posteriorly. Pronotum black, with an interrupted white transverse band behind eyes. Elytra brownish, heavily marked with black and with a few white areolar spots, two spots on each clavus along commissural line usually conspicuous. Venter black, face black, with three pale arcs extending up over margin of vertex.

Female seventh sternite roundedly produced. Male plates slightly narrowed to broadly rounded apices. Aedeagus in lateral

view, fig. 260, with a long slender basal portion, and a bulblike portion arising at about half its length; apical end broad, concavely excavated, the outer margins with projecting points.

Recorded only from Illinois, this is a rather abundant species in the low flood-plain woodland valleys of southern Illinois on a species of *Solidago*.

Illinois Records.—DANVILLE: Aug. 17, 1934, DeLong & Ross, 2 ♀. DOLSON: Rocky Branch, July 18, 1934, DeLong & Ross, 3 ♂, 4 ♀; July 24, 1936, DeLong & Mohr, 15 ♂, 46 ♀. URBANA: Sept. 10, 1934, H. H. Ross, 1 ♀. WILMINGTON: Aug. 20, 1934, DeLong & Ross, 1 ♂.

15. *Scaphoideus torqus* DeLong & Beery

Scaphoideus torqus DeLong & Beery (1936, p. 337).

Length 6.5 mm. Vertex pale, transverse band on disc rather narrow and slightly produced anteriorly at middle. Pronotum and scutellum tawny. Elytra pale, each darker on posterior half; veins brown. Face pale brownish. Marginal line above vertex narrow, interrupted, the line below margin entire, heavy.

Male plates tapered to bluntly pointed apices. Aedeagus in ventral view, fig. 268, composed of two portions that are separated at base but curve inwardly and then cross anterior to the laterally directed apices; apical portion of dorsal process not bearing a dorsal tooth. Upper apical portion of each pygofer with a distinct tooth. The female is unknown.

Described from Pennsylvania, this species has also been taken in northern Illinois in a woodland area.

Illinois Record.—GRAND DETOUR: Castle Rock, July 2, 1932, Dozier & Mohr, 1 ♂.

16. *Scaphoideus elongatus* DeLong & Beery

Scaphoideus elongatus DeLong & Beery (1936, p. 337).

Length 6.5–7.0 mm. Vertex with median transverse tawny band narrow, strongly produced anteriorly at middle. Pronotum and scutellum brownish, mottled with white, apical half of scutellum paler. Elytra white, veins dark brown, fuscous blotches on each

elytron forming an indefinite oblique band from anterior claval area to median costal area. Face pale, slightly smoky; a slender black line just beneath margin of vertex, the one above a little broader on either side of median line, where it is broken.

Female seventh sternite almost truncate, slightly produced and slightly and concavely rounded at middle. Male plates gradually narrowed to pointed apices. Aedeagus in ventral view, fig. 273, composed of a pair of processes that taper to pointed apices, which overlap; these curved and contiguous at middle, then separated anterior to and posterior to this point. Pygofers long and pointed.

This species has been found in Virginia, Mississippi, and Illinois.

Illinois Record.—STARVED ROCK STATE PARK: July 14, 1932, Dozier & Park, 1 ♂.

17. *Scaphoideus cylindratus* DeLong & Beery

Scaphoideus cylindratus DeLong & Beery (1936, p. 338).

Length 6.0–6.5 mm. Vertex pale, transverse band narrow, pale orange in color, and slightly produced at middle. Pronotum uniform brown; scutellum paler, with darker basal angles. Elytra rather uniform dull brown, each with veins and apex darker but almost devoid of areolar spots. Face pale brown, with two contiguous lines beneath vertex margin; line above margin slightly broken at middle.

Female seventh sternite broadly and roundedly produced and black margined on central half. Male plates convexly rounded and tapered to pointed apices. Aedeagus in ventral view, fig. 269, composed of a pair of rather short broad cylindrical processes, each bluntly pointed and slightly curved upward at apex.

This species has been taken in several New England states and in Illinois.

Illinois Record.—URBANA: on cottonwood, July 12, 1920, Auden, 1 ♂.

18. *Scaphoideus chelus* DeLong & Beery

Scaphoideus chelus DeLong & Beery (1936, p. 339).

Length 6–7 mm. Vertex pale, with a rather broad and poorly defined tawny transverse band between eyes. Pronotum

and scutellum brown, the former with a paler indistinct band. Elytra brownish, veins dark brown. Face slightly tawny, a dark line just below vertex and a slender one above, the latter broken at middle.

Female seventh sternite with posterior margin slightly produced to form a median rounded lobe, which is slightly emarginate at apex. Male plates convexly rounded to blunt apices. Aedeagus in ventral view, fig. 276, with a pair of separated processes arising from basal portion; these extend caudally and bear at their apices a pair of broad, curved, pincer-like processes that taper to sharp-pointed proximal apices. Pygofers long, sharply pointed.

This species has been taken only in the southern portion of the state in open woodland on dense herbaceous vegetation. It was described from Illinois.

Illinois Record.—DOLSON: Rocky Branch, July 18, 1934, DeLong & Ross, 1 ♂, 1 ♀.

19. *Scaphoideus transeus* DeLong & Beery

Scaphoideus transeus DeLong & Beery (1936, p. 339).

Length 5.5 mm. Vertex white, transverse median band orange at sides, darker and produced anteriorly at middle. Pronotum and scutellum pale brown. Elytral veins, and spot on costa at middle, dark brown. Face pale, a narrow black line beneath the margin of vertex and a broader one ventrad to this; marginal line on vertex broken at middle and broadened on either side of apex.

Female seventh sternite with posterior margin slightly produced, median fourth with a rather broad shallow notch. Male plates narrowed from near base to form long pointed tips with blunt apices. Aedeagus in ventral view, fig. 278, composed of a pair of processes that are broad and proximal at base and diverge to apices of plates, where they bend inwardly, cross each other, and taper to long pointed apices.

This species is known to occur in a habitat very similar to that of *chelus* and has been taken in central and northern Illinois. It is also known from Iowa and the District of Columbia.

Illinois Records.—DOLSON: Rocky Branch, July 18, 1934, DeLong & Ross, 1 ♂,

1 ♀. GALENA: hillside pasture, July 10, 1934, DeLong & Ross, 1 ♂.

20. *Scaphoideus densus* DeLong & Beery

Scaphoideus densus DeLong & Beery (1936, p. 340).

Length 6.0–6.5 mm. Vertex pale, with broken marginal line, transverse tawny band narrow, obliquely sloping to margin on either side, and strongly produced at middle. Pronotum and scutellum brownish. Elytra white, washed with pale brown, each with a spot on anterior part; clavus and apex of each elytron dark brown. Face pale, with three dark lines on upper portion.

Female seventh sternite slightly produced, rounded, and black margined. Male plates with apical halves sloping to bluntly pointed apices. Aedeagus, fig. 277, more than one-third longer than connective, two branched, each arm broadened on inner margin one-third the distance from apex and tapered to a sharply pointed tip; in lateral view the aedeagus is broadened near apex, curved, and tapered to pointed tip; dorsal process bearing a dorsal spine on apical portion.

Recorded from Ohio, Quebec, and Illinois, this species has been taken at several localities in this state in open woodlands. It is closely related to *chelus*.

Illinois Records.—BLUFF SPRINGS: June 10, 1932, Ross & Mohr, 1 ♂. EICHORN: Hicks Branch, June 13, 1934, DeLong & Ross, 1 ♂. ELIZABETHTOWN: May 27–31, 1931, Dozier, 1 ♀; June 25, 1932, Ross, Dozier, & Park, 2 ♂, 1 ♀.

21. *Scaphoideus major* Osborn

Scaphoideus immistus var. *major* Osborn (1900a, p. 205).

Length 6.0–6.5 mm. Vertex strongly produced, bluntly angled, almost as long at middle as basal width between eyes; a brown band just below ocelli, and another just above, broken at middle; transverse band tawny, notched on either side of a broad median tooth, which extends almost to marginal band. Elytra long, broadly rounded at apex; subhyaline, with dark veins, apical margins brownish.

Female seventh sternite slightly produced and slightly but broadly notched at middle; faintly concave on either side of median third. Male plates not quite as long as

combined basal width, strongly and convexly rounded to bluntly pointed apices. Styles, fig. 263, tapered from base, each strongly and suddenly narrowed on outer margin to form on the apical fifth a short outwardly curved finger-like process. Aedeagus about the length of the connective, two branched, each branch in ventral view appearing broadened on inner margin about one-third the distance from apex and tapered to pointed tip; in lateral view aedeagus appearing tapered to a long attenuated pointed apex; dorsal process semicircular, tapered to apex, which is blunt, slightly enlarged, and with a very small dorsal spine.

This species was described from Iowa.

Illinois Records.—ALTON: June 26–27, 1934, DeLong & Ross, 2♂. APPLE RIVER CANYON STATE PARK: July 11, 1934, DeLong & Ross, 1♂. URBANA: Aug. 5, 1889, Hart, 1♀; Aug. 28, 1890, Hart & Shiga, 2♀; Aug. 10, 1891, Hart & McElfresh, 2♀; Aug. 29, 1891, 1♀.

22. *Scaphoideus nigricans* Osborn

Scaphoideus nigricans Osborn (1911, p. 258).

Length 6.0–6.5 mm. Vertex broad, white, marginal band interrupted at middle; median transverse band dark brown, narrow, sinuate, produced anteriorly at middle, forming a broad tooth, and curved posteriorly on either side. Pronotum pale anteriorly, darker posteriorly. Elytra white, veins reflexed, costal veinlets and spots in several cells brown. Face pale, smoky above, a heavy black line beneath vertex margin.

Female seventh sternite angularly produced. Male plates tapered from bases to bluntly pointed apices. Aedeagus, fig. 279, two branched, processes long, curved inwardly, crossed near apex and tapered to pointed tips; in lateral view the processes curve upward and anteriorly.

Recorded first from North Carolina and Tennessee, this species has since been taken at two localities in central Illinois.

Illinois Records.—URBANA: cottonwood, July 12, 1920, F. K. Auden, 1♀. WHITE HEATH: June 4, 1939, J. C. Dirks, 1♀.

23. *Scaphoideus cinerosus* Osborn

Scaphoideus cinerosus Osborn (1900a, p. 208).

Length 4.0–4.5 mm. Ashy gray, with faint marking. Vertex almost white, with

a faint brownish cross band between the eyes, and a very faint marginal line. Pronotum light gray, with brownish spots on posterior portion. Elytra with veins brown, and pale brownish spots on discal, inner anteapical, and apical cells.

Female seventh sternite roundedly produced. Male plates broadly rounded at apices. Aedeagus in lateral view, fig. 249, enlarged at about one-half its length, then constricted; apical third broadened, apex curved on dorsal portion to a ventrally sharp-pointed tip; dorsal process enlarged at apex, with anterior and posterior processes and a median sunken tooth.

This species has been taken in small numbers in Illinois in woodland areas. It is known also from Iowa.

Illinois Records.—URBANA: June 7, 1889, C. A. Hart, 1♂; Aug. 18, 1892, C. A. Hart, 4♀; June 23, 1918, 1♂; cottonwood, June 12, 1920, C. P. A., 1♀; Aug. 9, 1920, J. R. Malloch, 1♀; Aug. 15, 1940, 1♂.

24. *Scaphoideus melanotus* Osborn

Scaphoideus melanotus Osborn (1900a, p. 206).

Length 5 mm. Pale brown, with a black face having one minute white point just below apex of vertex and one on tip of clypeus. Vertex whitish, with a rather faint narrow brownish band, darker at center; marginal line narrow. Pronotum whitish, with anterior and posterior fulvous bands. Elytra with whitish marginal lobes on each clavus and spots on costal and post-nodal cells, fig. 228. Fulvus and fuscous markings as in *immistus*, to which this species is rather closely related.

Female seventh sternite roundedly produced and medially notched. Male plates with broadly rounded apices. Aedeagus in lateral view, fig. 259, broad, apex broadly and bluntly rounded; dorsal process with two short apical divergent processes. Pygofer each with a pair of spines at base, spines large and turned upward.

An inhabitant of herbaceous vegetation in wooded areas, this species is known from the eastern United States and occurs as far west as Texas. Recorded eastern localities include Maryland, Pennsylvania, and Tennessee. The species is rare in Illinois.

Illinois Records.—DOLSON: Rocky Branch, July 18, 1934, DeLong & Ross, 1♀. SPRINGFIELD: Sept. 25, 1934, H. H. Ross, 1♀.

25. *Scaphoideus littoralis* Ball

Scaphoideus littoralis Ball (1932, p. 15).
Scaphoideus brevidens DeLong & Mohr (1936, p. 971).

Length 4.75–5.5 mm. Pale tawny, vertex pale, with black marginal line and transverse band behind middle tawny. Elytra opalescent, each with an apical smoky band extending to a point just before the cross nervures; nervures rusty brown; two lobate ivory spots on the commissure, and with oval spots on the claval sutures. Face pale smoky in the female, creamy in the male.

Female seventh sternite with the posterior margin roundedly produced. Male plates with rounded apices. Aedeagus in lateral view, fig. 275, with a long slender ventral process, which is bifid on apical third, the bifurcate processes not as long as the dorsal portion of the aedeagus; dorsal process broadened at apex, which is concavely rounded between a small anterior toothlike projection and a posterior finger-shaped process, the latter curving dorsally and anteriorly.

One of the most common species of the genus, *littoralis* is found abundantly throughout Illinois. It is widely distributed in the eastern states and ranges west to South Dakota.

Illinois Records.—Many males and females, taken May 29 to October 1, are from Adair, Algonquin, Alton, Antioch, Apple River Canyon State Park, Cedar Lake, Centralia, Champaign, Charleston, Dixon Springs, Dolson, Dubois, Elizabethtown, Fox Lake, Galena, Golconda, Grafton, Hardin, Harrisburg, Havana, Herod, Kampsville, Kankakee, Karnak, La Rue, Mahomet, Meredosia, Metropolis, Mount Carmel, Muncie, Normal, Oak Lawn, Olive Branch, Palos Park, Parker, Quincy, Rockton, Rosiclare, Springfield, Thebes, Urbana, Vienna, Volo, Wauconda, West Union, White Heath, and Zion.

26. *Scaphoideus productus* Osborn

Scaphoideus productus Osborn (1900a, p. 200).

Length 6 mm. Female heavily marked and with a strongly produced seventh sternite. Vertex yellowish, with a broad fuscous band between eyes, this band produced at middle almost far enough to meet marginal band. Pronotum yellowish, with lateral fuscous areas. Elytra whitish, with fulvous

blotches on discal and apical cells, and fuscous patches on each clavus, inner discal cell, and costal crossvein and apical vein.

Female seventh sternite produced at center and strongly keeled. The first sex of this species to be described was the male, but the type male cannot be located, and the sexes have not been associated.

This species occurs in Iowa, is widely distributed over the eastern states, and undoubtedly will be found in Illinois.

27. *Scaphoideus immistus* (Say)

Jassus immistus Say (1831, p. 306).

Length 4.75–5.5 mm. Vertex blunt, white, with a prominent black rounded marginal line; transverse band broad, dark, strongly produced at middle to form a blunt tooth, band shading to fuscous and usually covering most of the basal portion. Pronotum brown, usually with a broken pale band anterior to middle; an apical and a median lateral spot on each side white. Elytra fuscous, veins darker, apex of each elytron black; several areolar spots present. Face smoky, darker above.

Female seventh sternite roundedly produced, black margined, forming a somewhat produced lobe at center. Male plates with broadly rounded apices. Aedeagus in lateral view, fig. 253, long and slender, slightly curving ventrally, and pointed at apex; dorsal process with bifurcate processes at apex, the latter short, truncate, and divergent.

This is one of the two most common species of the genus and has been taken in considerable numbers throughout the state. It occurs abundantly in the eastern United States and ranges south and west to Texas and California.

Illinois Records.—Many males and females, taken June 14 to October 2, are from Algonquin, Cave in Rock, Champaign, Dubois, Fairfield, Fountain Bluff, Harrisburg, Havana, Henry, Herod, Justice, Karnak, Kinmundy, Meredosia, Metropolis, Mount Carmel, New Haven, Newton, Oakwood, Quincy, Rosiclare, Seymour, Shawneetown, Sumner, Urbana, Vienna, Volo, and White Heath.

28. *Scaphoideus sensibilis* Ball

Scaphoideus sensibilis Ball (1932, p. 14).

Length 5–6 mm. Black, marked with ivory white. Vertex ivory white, with sub-

marginal dark line; median transverse band dark brown or black, band narrow next to eyes, widened at middle, and with an acute median projection. Scutellum with a large median shield of ivory and a pair of large black spots just inside the basal angles. Elytra heavily clouded with dark brown or black, with two lobate median ivory spots and four pairs along the suture on each clavus; a hyaline spot on costa.

Female seventh sternite with posterior margin angularly produced, lateral margins of produced portion concave. Male plates long and narrow, apices bluntly rounded. Aedeagus in lateral view, fig. 261, long with apex enlarged, obliquely sloping, bluntly pointed on ventral margin.

This species was described from Florida, and a few specimens have been taken in Illinois.

Illinois Record.—JONESBORO: July 31, 1934, DeLong & Mohr, 1 ♂, 2 ♀.

29. *Scaphoideus obtusus* Osborn

Scaphoideus obtusus Osborn (1900a, p. 207).

Length 5 mm. Pale, with the basal half of each elytron appearing gray, the posterior portion darker. Vertex white, with a broad fuscous band between eyes; band produced anteriorly and posteriorly at middle. Pronotum fuscous, with a median longitudinal stripe and posterior margin white. Elytra white to pale gray, the basal half of each with a few dark markings, a heavy black band across posterior portion extending cephalad to apex of clavus, giving the insect a banded appearance. Face smoky.

Female seventh sternite roundedly produced and broadly black margined. Male plates long, broadly rounded at apices. Aedeagus in lateral view, fig. 251, enlarged at one-third its length, then narrowed and produced to apex, which is enlarged, curved on dorsal surface, and forms a pointed tip on ventral margin; dorsal process bifurcate, posterior process longer than anterior process.

This species, found in small numbers in woodland habitats in Illinois, is known also from Florida, New York, and Iowa.

Illinois Records.—ELMIRA: Aug. 2-3, 1883, 1 ♂. THOMASBORO: July 20, 1914, 1 ♀. URBANA: on cottonwood, July 12, 1920, F. K. Auden, 2 ♂, 2 ♀; Aug. 13, 1920, 1 ♀.

30. *Scaphoideus opalinus* Osborn

Scaphoideus opalinus Osborn (1905b, p. 525).

Length 5.0-5.5 mm. Grayish brown, with an opalescent tint. Vertex white to gray, marginal line distinct, fuscous bands between eyes faint, often broken at middle and broadest next to eyes. Pronotum pale brownish, disc dull gray. Scutellum mostly white, basal angles fuscous. Elytra fuscous, opalescent, a pair of brownish spots on commissure at apex of each claval vein, between which are two rounded white or gray lobate spots; a large hyaline area on middle of each costa; apical and antepical reflexed costal veinlets and apex black. Face pale smoky.

Female seventh sternite slightly and roundedly produced, almost truncate. Male plates narrowed, but broadly rounded. Aedeagus, fig. 272, with ventral bifurcate apical process short, not as long as dorsal portion; dorsal process abruptly enlarged at apex and lacking an anterior process at tip but with a well-developed finger-like posterior process.

This species has been found occasionally upon *Juniperus* through the southern half of the state. It has been taken also in immature stages from this plant. Previous records show its occurrence in Florida, New Jersey, and New York.

Illinois Records.—DIXON SPRINGS: July 9, 1935, DeLong & Ross, 2 ♂, 2 ♀. HILLSBORO: on juniper, June 26, 1934, DeLong & Ross, 7 ♂, 1 ♀. LAWRENCEVILLE: on juniper, Sept. 24, 1932, Frison & Mohr, 1 ♀. STARVED ROCK STATE PARK: July 14, 1932, Dozier & Park, 1 ♂.

31. *Scaphoideus luteolus* Van Duzee

Scaphoideus luteolus Van Duzee (1894b, p. 210).

Length 4.0-4.5 mm. Brownish, elytra with a few pale areas. Vertex white, marginal line heavy. Fuscous band between eyes broad, width almost half the length of vertex, medially produced. Pronotum almost uniformly brownish. Scutellum brownish fuscous anteriorly, paler posteriorly. Elytra brownish fuscous, veins brown, reflexed costal veinlets, apex of each elytron, and apical veins brownish; small white areolar spots just before and also posterior to cross nervures of apical cells.

Female seventh sternite roundedly pro-

duced, with a short V-shaped notch at apex. Male plates broadly rounded at apexes. Aedeagus in lateral view, fig. 248, broadened at one-third its length, somewhat narrowed at two-thirds its length, and again broadened to enlarged apex, which is produced dorsally and bluntly pointed; dorsal process slender, with two long slender bifurcate teeth.

Taken in small numbers in herbaceous woodland habitats, this species has been recorded only from the Middle West.

Illinois Records.—ALTON: June 26, 1934, DeLong & Ross, 1♂, 1♀. ASHLEY: Aug. 17, 1917, 1♂. CEDAR LAKE: in bog, Aug. 6, 1906, 1♂. HAVANA: July 2, 1934, DeLong & Ross, 1♀. MEREDOSIA: Aug. 20, 1917, 1♂. MONTICELLO: June 11, 1934, Frison & DeLong, 1♀. PANA: July 21, 1937, Mohr & Burks, 1♂. URBANA: on cottonwood, July 12, 1920, F. K. Auden, 1♂; Aug. 11, 1932, H. H. Knight, 1♀.

32. *Scaphoideus minor* Osborn

Scaphoideus immistus var. *minor* Osborn (1900a, p. 205).

Scaphoideus immistus var. *incisus* Osborn (1900a, p. 206).

Length 4.25–5.0 mm. Vertex more obtuse than in *immistus*, white to yellow, with a conspicuous marginal line and a tawny transverse band produced at middle, forming a blunt tooth. Pronotum brown, a transverse narrow white band at middle. Elytra fuscous, veins brown, marked with numerous brown spots and white areoles; apex of each elytron black margined. Face pale, with dark lines below vertex margin.

Female seventh sternite broadly and roundedly produced. Male plates convexly rounded to bluntly pointed apexes. Aedeagus in ventral view, fig. 266, with a pair of slender processes arising at base and separated for most of their length, curved inwardly, meeting at their apexes, which are sharp pointed and curved slightly outward.

Although described from Iowa as a variety of *immistus*, this species is of the form and general type of *major* but with entirely different characters. It is found in Illinois in woodland habitats.

Illinois Records.—Males and females, taken May 18 to October 1, are from Alton, Dolson, Golconda, Hardin, Harrisburg, Havana, Kampsville, Karnak, Meredosia, Monticello, New Holland, Pike, Urbana, Vienna, Volo, White Heath, and Zion.

33. *Scaphoideus ochraceus* Osborn

Scaphoideus ochraceus Osborn (1898, p. 242).

Length 5–6 mm. Vertex white to yellow, with a conspicuous dark marginal line; transverse band broad, ochraceous, produced forward at middle on anterior margin and indented on posterior margin. Pronotum mostly ochraceous, with a broken transverse median pale band. Elytra tawny ochraceous, veins mostly brown, with several white areoles and brown spots. Face pale yellowish.

Female seventh sternite angularly produced. Male plates tapered from near base to bluntly pointed apexes. Aedeagus in ventral view, fig. 271, with a pair of short slender processes that are separated at base, curved on apical portions, and cross each other just before apexes, the latter narrow and bluntly pointed.

A woodland species usually found in small numbers, *ochraceus* occurs in the eastern United States.

Illinois Records.—APPLE RIVER CANYON STATE PARK: July 11, 1934, Frison & DeLong, 1♀. DOLSON: Rocky Branch, July 18, 1934, DeLong & Ross, 3♂. PALOS PARK: Aug. 8, 1935, DeLong & Ross, 1♀.

42. *LONENUS* DeLong

Lonenus DeLong (1939a, p. 33).

The vertex is flat and similar in general appearance to that of *Scaphoideus*. The venation also is similar to that of *Scaphoideus*. The male plates are long and rather narrow. The long narrow apical portion of each style is longer than the basal portion. The characters of the dorsal portion of the aedeagus distinguish *intricatus*, the only known species in the genus, from all species in the related genus, *Scaphoideus*.

1. *Lonenus intricatus* (Uhler)

Scaphoideus intricatus Uhler (1889, p. 34).

Length 5.5–6.0 mm. White, with anterior portion of the elytra dark. Vertex white, with a conspicuous but interrupted marginal line; transverse band pale, broken, often with central portion wanting. Pronotum white, transverse; tawny band on posterior portion faint and broken. Scutellum white. Elytra with a large oblique dark brown area on basal half of each extending posteriorly to central antecapical cell and

extending into middle of clavus; veins on apical portion, reflexed veinlets and apical margin brown. Face white, a black spot below each ocellus, and black lines below vertex margin.

Female seventh sternite roundedly produced and black margined. Male plates, fig. 246, long, convexly curved from bases, apices bluntly pointed. Apical half of styles forming long, slender, straight processes. Aedeagus in ventral view, fig. 246, with a pair of long slender processes arising at base, curving divergently at base and crossing each other before apices; apices slender.

The only species in the genus, *intricatus* is distributed rather commonly throughout the eastern half of the United States. In Illinois, it is known only from the northern half of the state.

Illinois Records.—ANTIOCH: Aug. 24, 1935, DeLong & Ross, 1 ♀. APPLE RIVER CANYON STATE PARK: Aug. 22, 1935, DeLong & Ross, 1 ♂, 1 ♀. DONGOLA: Aug. 23, 1916, 1 ♀. HAVANA: Aug. 31, 1917, 1 ♀. NORTHERN ILLINOIS: 1 ♀. PALOS PARK: Aug. 8, 1935, DeLong & Ross, 1 ♀. URBANA: July 21, 1889, Hart, 1 ♀; July 29, 1934, T. H. Frison, 5 ♀; Aug. 12, 1934, T. H. Frison, 1 ♂, 4 ♀; at light, Aug. 3, 1936, H. H. Ross, 1 ♀. WARREN: Aug. 22, 1935, DeLong & Ross, 1 ♂, 1 ♀.

43. OSBORNELLUS Ball

Osbornellus Ball (1932, p. 17).

Head slightly narrower than pronotum. Vertex flat, angled in front, and forming an acute angle with face. Male plates elongate, forming filamentous processes.

The species of this genus live for the most part upon herbaceous plants in open and wooded areas. Thirty species of *Osbornellus* have been recorded for the United States; six are known to occur in Illinois and at least one other may eventually be found here.

KEY TO SPECIES

1. Vertex marked with orange or orange red 2
Vertex brown, not marked with orange or orange red 5
2. Vertex with a transverse orange-red band 3
Vertex with two longitudinal orange spots or stripes 1. **jucundus**
3. Female seventh sternite with a median notch or excavation; length of each male plate to base of attenuated portion

- one-third greater than widest portion, as in fig. 286 4
Female seventh sternite without notch; length of each male plate to attenuated portion scarcely greater than widest portion, fig. 281 3. **rotundus**
4. Female seventh sternite with a deep narrow median notch; apical portion of each male style, fig. 285, with straight margin not notched, and without teeth 2. **auronitens**
Female seventh sternite roundedly produced either side of a broad shallow median excavation at the apex of which is a brownish longitudinal spot or a slight incision; apical portion of each male style, fig. 286, bearing a short pointed tooth on inner margin just before apex 4. **limosus**
 5. Vertex brown, concolorous 5. **unicolor**
Vertex not concolorous, marked with paler spots or lines 6
 6. Vertex dull yellow to brown, darker markings inconspicuous; median dark band between ocelli wanting 6. **consors**
Vertex white or pale, brown markings conspicuous; median darker band between ocelli conspicuous 7. **clarus**

1. *Osbornellus jucundus* (Uhler)

Scaphoideus jucundus Uhler (1889, p. 34).

Length 5.0–6.25 mm. Tawny yellow, elytra with numerous milky white spots. Vertex marked by two longitudinal orange spots. A narrow black line just above margin of vertex and a more distinct one on upper margin of face. Female seventh sternite with posterior margin broadly and convexly rounded. Male plates slender, narrowed to long attenuate apices. Aedeagus, fig. 282, curved ventrally, narrowed to apex, where a pair of divergent apical processes arise, curve laterally and cephalad.

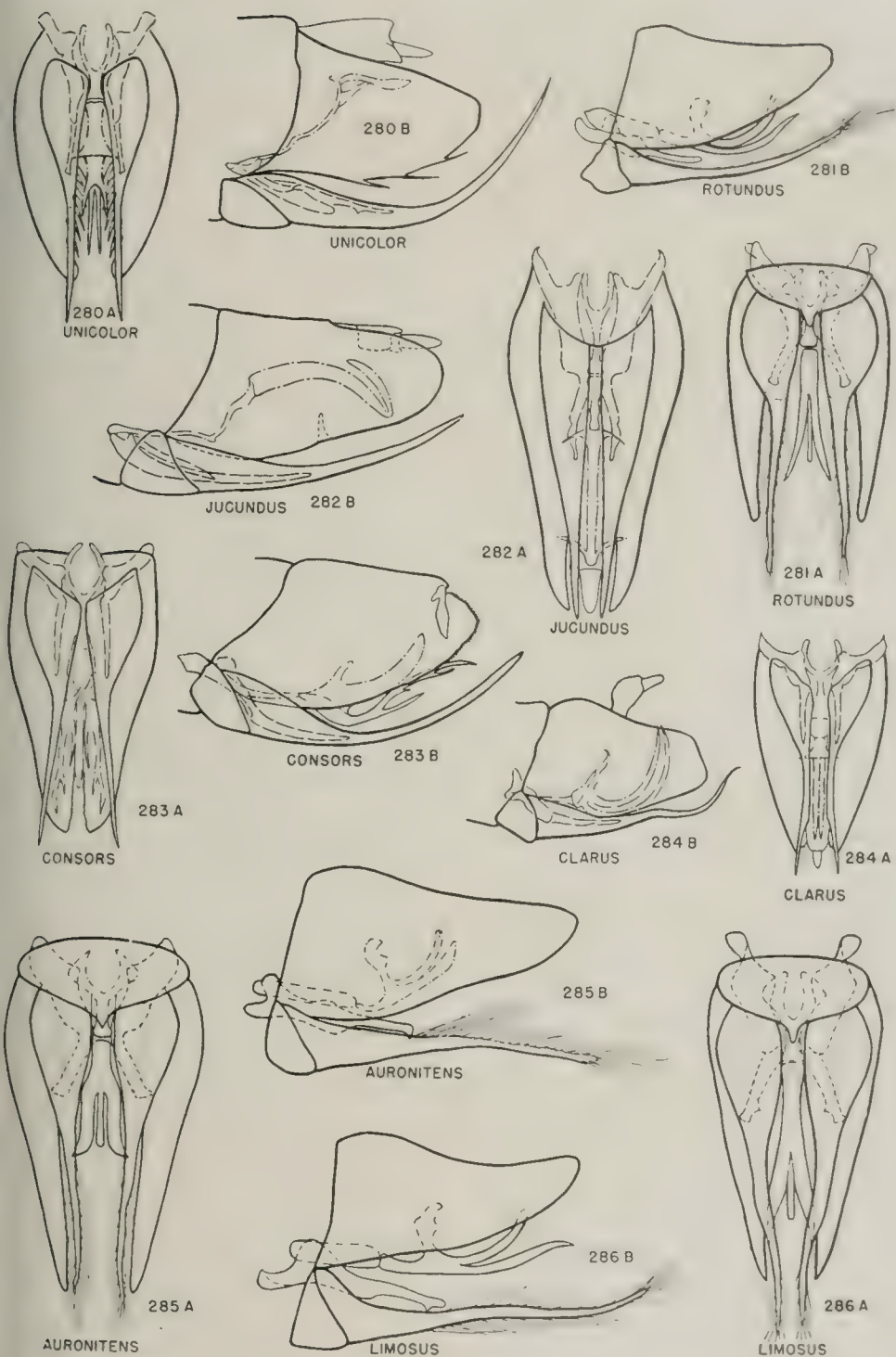
Occurring in small numbers in woodland areas on herbaceous vegetation, *jucundus* is distributed over the eastern United States and west to Missouri and Iowa.

Illinois Records.—ALTON: June 26, 1934, 1 ♂. ANVIL ROCK: Oct. 3, 1934, Frison & Ross, 1 ♀. HAVANA: Aug. 30, 1917, 2 ♂. HEROD: Aug. 4, 1934, DeLong & Mohr, 1 ♀. OREGON: Aug. 23, 1935, DeLong & Ross, 1 ♀. PALOS PARK: Aug. 8, 1935, DeLong & Ross, 1 ♂. TAMAROA: Sept. 22, 1882, 1 ♂ (Acc. No. 3135).

2. *Osbornellus auronitens* (Provancher)

Scaphoideus auronitens Provancher (1889, p. 277).

Length 6 mm. Light yellow, and with a prominent orange-red transverse band; ver-



Figs. 280-286.—*Osbornellus*, male genitalia; both internal and external structures shown. A, ventral aspect; B, lateral aspect.

tex anteriorly margined with a black line; a black band on margin of vertex and another just above margin. Pronotum marked with reddish. Elytra each with three reflexed costal veinlets and three pairs of black spots along claval suture.

Female seventh sternite cleft to near its base, forming two broadly rounded lobes. Male plates elongate, triangular, with long attenuated apices. Styles with apical portion of each bent outwardly, almost parallel margined. Aedeagus in lateral view, fig. 285, curved dorsally and with a pair of broad processes arising laterally just before base of shaft, flaring slightly, apices pointed.

This is the most common species of the genus in Illinois and has been taken abundantly throughout the state. It is found in the eastern United States only.

Illinois Records.—Many males and females, collected from June 14 to November 17, are from Antioch, Apple River Canyon State Park, Bloomington, Channel Lake, Dixon Springs, Dolson, Elizabethtown, Fox Lake, Grand Tower, Herod, Hopedale, Kankakee, Makanda, Marshall, Monticello, Mount Carmel, Muncie, Oakwood, Temple Hill, Urbana, Vienna, and White Heath.

3. *Osbornellus rotundus* Beamer

Osbornellus rotundus Beamer (1937, p. 93).

Length 5.0–5.5 mm. Tawny and of the same form, color, and appearance as *auronitens*, but with the female seventh sternite not cleft and vertex more acute. Vertex with three dark parallel lines and a transverse orange-red band between eyes. Pronotum with the anterior margin orange and with darker spots posteriorly. Each clavus with three dark spots on commissural suture.

Female seventh sternite with posterior margin truncate or slightly produced. Male plates long, acutely tapered, with long filamentous apices. Each style with apical half narrowed, tapering to slightly knobbed tip. Aedeagus, fig. 281, long and slender, a pair of lateral processes arising a short distance from the base and gradually tapering to sharp apices.

For many years this species has been confused with *auronitens*, which it closely resembles. It occurs on herbaceous vegetation in open woodlands, and it is widely distributed over the eastern United States.

Illinois Records.—DOLSON: Rocky Branch, July 18, 1934, DeLong & Ross,

2 ♀. GRAFTON: on wild grape, July 2, 1932, Frison & Ross, 1 ♂.

4. *Osbornellus limosus* DeLong

Osbornellus limosus DeLong (1941, p. 179).

Length 5–6 mm. Resembling *auronitens* in form and general appearance but with vertex more broadened and with distinctive male and female genitalia. Vertex almost one-third wider between eyes than median length. In color similar to *auronitens*, with broad orange-red transverse band on vertex and with orange-red blotches on pronotum and basal angles of scutellum. Elytra pale brown, with veins dark brown and three pairs of brown spots along commissural line of each clavus as in *auronitens*.

Female seventh sternite with posterior margin roundedly produced on either side of a broad shallow median excavation, with a brownish longitudinal spot or slight incision at apex. Male valve, fig. 286, roundedly produced, with a median produced pointed apical tooth. Plates long and tapered to acute tips. Each style with outer margin notched just beyond middle, forming a long narrow apical finger-like process that is bent outwardly from notched portion; each style bears a short pointed tooth on inner margin just before apex. Aedeagus with a short rather broad process extending dorsally near base; apical portion consisting of a single curved dorsal process and a ventral process that is bifurcate at about its middle, forming a pair of divergent processes, which are broad at base but tapered to slender pointed apices.

This species has been recorded from New Jersey, Pennsylvania, and northern Tennessee, and may eventually be found in the southern portion of Illinois.

5. *Osbornellus unicolor* (Osborn)

Scaphoideus consors var. *unicolor* Osborn (1900a, p. 196).

Length 5 mm. Face, vertex, and pronotum uniform brown, elytra brownish hyaline, nervures dark; reflexed costal veins and apices broadly fuscous. Female seventh sternite with posterior margin almost truncate, often with an indication of a slight central tooth, on either side of which the segment is emarginate. Each male plate narrow, twice as long to attenuation as greatest width. Styles with truncate apices.

Aedeagus, fig. 280, composed of a short ventral and a longer dorsal process, each of which is bifid. Ventral margin of each pygofer with long slender caudally directed spines.

A common species on herbaceous vegetation in open woodland, *unicolor* has been recorded from the eastern United States and Texas.

Illinois Records.—APPLE RIVER CANYON STATE PARK: July 11, 1934, DeLong & Ross, 1 ♂. ELIZABETHTOWN: July 8, 1935, DeLong & Ross, 1 ♂.

6. *Osbornellus consors* (Uhler)

Scaphoideus consors Uhler (1889, p. 36).

Length 5.5–6.0 mm. Brownish, marked with fuscous and yellowish. Lines and markings on vertex blending with and not much darker than ground color. Pronotum with a pale spot behind each eye and a pale median longitudinal line. Elytra subhyaline, pale spots on each clavus indistinct, nervures brown, apical margin and costal veinlets broadly black.

Female seventh sternite with posterior margin sinuate. Each male plate long, tip attenuate. Each style with apical two-thirds slender, straight, and tapered. Aedeagus, fig. 283, with a rather heavy body and with a pair of antler-like structures having many lateral processes arising near base and extending beyond apex of body of aedeagus.

This is a common species on herbaceous vegetation in wooded areas. Distributed through the eastern United States, it ranges west to Texas, Colorado, and Utah.

Illinois Records.—APPLE RIVER CANYON STATE PARK: July 11, 1934, Frison & DeLong, 4 ♂, 5 ♀. DIXON SPRINGS: July 29, 1934, DeLong & Mohr, 1 ♂. DOLSON: Rocky Branch, July 18, 1934, DeLong & Ross, 12 ♂, 3 ♀. FERN CLIFF: Aug. 3, 1934, DeLong & Mohr, 1 ♀. KANKAKEE: July 20, 1934, DeLong & Ross, 1 ♂. MARSHALL: Sept. 27, 1934, Frison & Ross, 1 ♀. NORTHERN ILLINOIS: 2 ♀. PALOS PARK: Aug. 8, 1935, DeLong & Ross, 3 ♂, 1 ♀. WHITE PINES FOREST STATE PARK: Aug. 27, 1934, DeLong & Frison, 1 ♀.

7. *Osbornellus clarus* Beamer

Osbornellus clarus Beamer (1937, p. 99).

Length 5.0–5.5 mm. Closely resembling *consors* but more distinctly marked and

without the branched aedeagus processes. Vertex with distinct white apex; margin and a median triangle just behind apex conspicuously white, these markings bordered by heavy fuscous lines; a rather definite darker area forming a banded pigmentation between the eyes. Scutellum pale, with dark basal angles. Elytra cinereous, with dark veins.

Female seventh sternite roundedly produced. Each male plate with a long slender attenuated apex. Each style with apical half slender and tapered. Aedeagus, fig. 284, with a pair of long slender curved processes arising ventrally and curving dorsally.

This species occurs on herbaceous plants in open woodland. Specimens of this species, collected in the eastern United States, have for many years been listed under the name *scalaris* Van Duzee; *scalaris* is a species distributed only in the southwestern United States.

Illinois Record.—DUNCANS MILLS: near Spoon River, Oct. 20, 1941, 1 ♀.

44. *PRESCOTTIA* Ball

Prescottia Ball (1932, p. 16).

Fig. 215. Head narrower than pronotum; vertex angular, broad and flat or concave, with a sharp margin acutely angled with front. Elytra each with outer anteapical cell, fig. 215, parallel with the costa; about four or five reflexed veinlets to costa and an equal number along costal area; cells anterior to the apical ones more or less reticulate, especially along claval suture.

Two described species belong to this genus, one of which occurs in the eastern United States and has been collected in Illinois.

1. *Prescottia lobata* (Van Duzee)

Scaphoideus lobatus Van Duzee (1894b, pp. 199, 211).

Length 5.5–6.0 mm. Pale yellow or white, marked with black lines and spots. Vertex yellowish, with a brown line above and parallel to margin, and a transverse brown line between eyes enlarged to a spot on disc. Elytra milky white, nervures broadly brown or black and with numerous heavy and large blackish blotches or inscribed lines; brown markings on each clavus heavy, forming three distinct white lobes along commissural line on inner margin. Female seventh ster-

nite with posterior margin almost truncate, slightly notched. Male plates, fig. 293, narrow, with slender recurved tips.

This species occurs in open woods or at woodland margins upon *Solidago caesia* and probably other species of plants. Collecting would indicate it is quite restricted in regard to its food plants.

Illinois Records.—STARVED ROCK STATE PARK: July 14, 1932, Dozier & Park, 1 ♂. ZION: July 25, 1934, Frison & DeLong, 1 ♂; Aug. 7, 1936, DeLong & Ross, 1 ♂.

45. *SANCTANUS* Ball

Sanctanus Ball (1932, p. 10).

Front margin of vertex round to bluntly angled, disc slightly convex, meeting front in an acute angle. Elytra each with two cross nervures between the first and second sectors; central anteapical cell constricted and divided; outer anteapical cell usually narrow at both ends, and usually having one or more reflexed veinlets to the costa as well as extra reticulations in some cells. Most species are marked by pigmented saddle patterns.

Ten species of this genus are recorded for the United States by Oman (1934) and DeLong & Knull (1945). Eight of these occur in the eastern states, and one of them has been taken in Illinois.

1. *Sanctanus sanctus* (Say)

Jassus sanctus Say (1831, p. 307).

Scaphoideus picturatus Osborn (1898, p. 243).

Length 4–5 mm. White, with a brownish band across elytra. Vertex rather sharply angled, white with two minute fuscous spots near apex. Pronotum with disc somewhat fuscous. Elytra white, each with a cruciform brownish band bordered with black; band covering posterior two-thirds of each clavus, a small round white spot at middle of band on commissural line. Female seventh sternite slightly notched at middle of posterior margin. Male plates, fig. 289, rather long and slender, longer than combined basal width; apices blunt.

This species occurs commonly in the southern fifth of the state on herbaceous plants. It is one of the most conspicuously marked of the Illinois species of leafhoppers.

Illinois Records.—Males and females, taken June 29 to October 6, are from Cache,

Carmi, Dubois, Elizabethtown, Meredosia, Metropolis, Olive Branch, Quincy, Rosiclare, and Thebes.

46. *PLATYMETOPIUS* Burmeister

Platymetopius Burmeister (1838, pl. 14).

Head narrow, face plain, supernumerary veinlets short and at right angles to costa. Each elytron has only one cross nervure between the sectors. The species of this genus are without vermiculate markings.

Two species are at present included in this genus for the United States and one of these occurs in Illinois. The other, *palliolatus*, is found in Texas.

KEY TO SPECIES

Color orange yellow, with white areolar spots 1. *vitellinus*
Color lemon yellow; pronotum and scutellum dark brown; a narrow brown stripe on each elytron along margin of scutellum and extending along suture to apex. 2. *palliolatus*

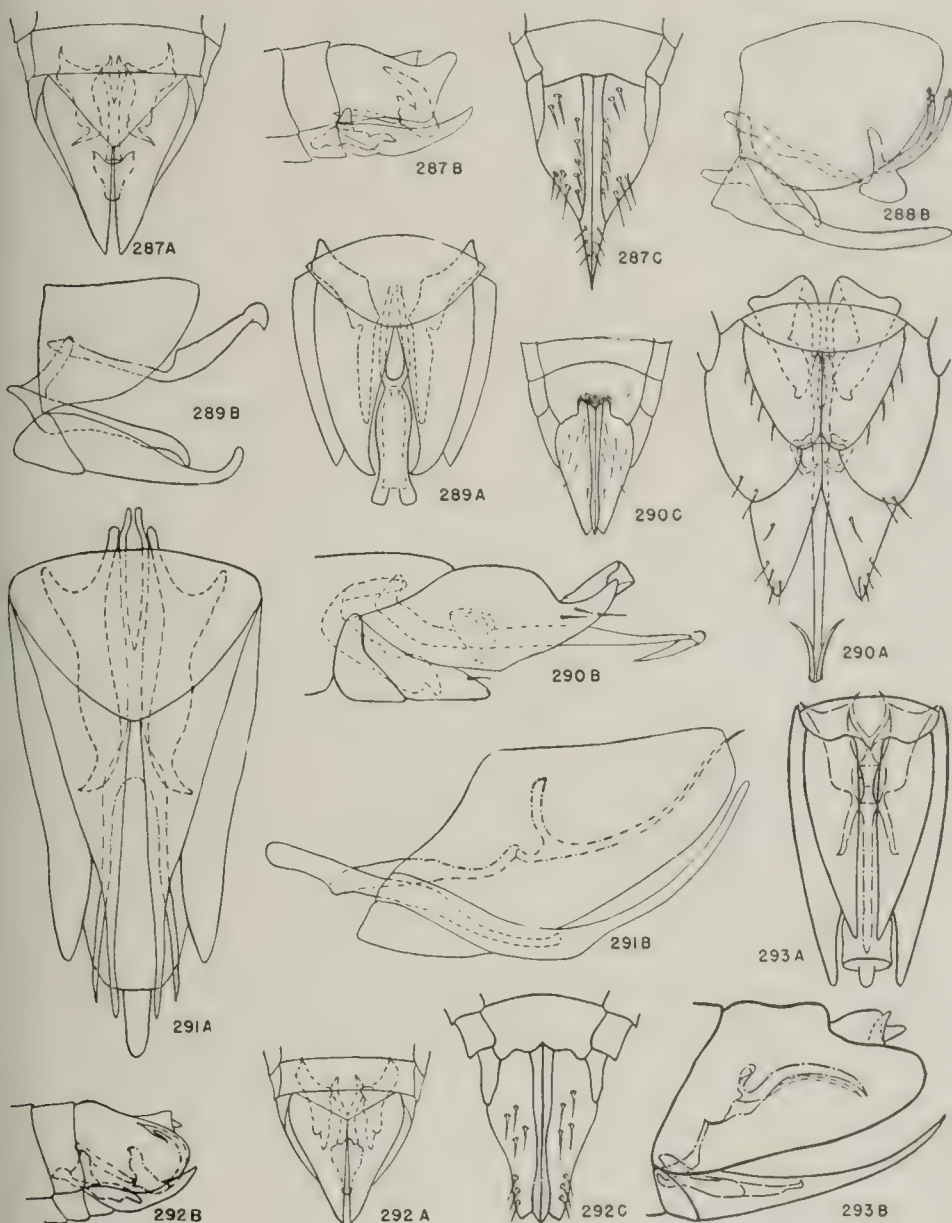
1. *Platymetopius vitellinus* (Fitch)

Acocephalus vitellinus Fitch (1851, p. 57).

Fig. 298. Length 5.5–6.5 mm. Orange yellow, with an oblique testaceous stripe on each elytron. Vertex and face pale yellow, usually a narrow black line just below margin of vertex. Pronotum yellow anteriorly, darker posteriorly. Scutellum pale yellow, the basal angles darker. Elytra yellow, with many white spots, each with a testaceous band at base, and another testaceous oblique band parallel to it from costa to apex of clavus. Female seventh sternite, fig. 296, with the posterior margin shallowly emarginate and with a narrow blunt tooth arising from the middle, the tooth longer than its basal width and bifid at apex. Male plates, fig. 297, convexly rounded, then narrowed to acute apices.

This species occurs on herbaceous vegetation in shrubby or open woodland areas. It has been taken from wild rose, but this may not represent a definite host plant. It is transcontinental in distribution.

Illinois Records.—APPLE RIVER CANYON STATE PARK: July 11, 1934, DeLong & Ross, 1 ♀. BEACH: July 25, 1934, Frison & DeLong, 1 ♀. FREEPORT: June 27, 1935, DeLong & Ross, 1 ♂. GALENA: July 10, 1934, DeLong & Ross, 1 ♀. GRAND DETOUR: July 12, 1934, DeLong & Ross, 1 ♀.



Athysaninae, male and female genitalia. The figures illustrate chiefly some generic characters. *A*, ventral aspect of male genitalia, both internal and external structures; *B*, lateral aspect of male genitalia, both internal and external structures; *C*, female genitalia, external structures only. Internal structures indicated by broken lines.

Fig. 287.—*Exitianus obscurinervis*.

Fig. 288.—*Opsius stactogalus*.

Fig. 289.—*Sanctanus sanctus*.

Fig. 290.—*Acurhinus pyrops*.

Fig. 291.—*Japananus hyalinus*.

Fig. 292.—*Remadosus magnus*.

Fig. 293.—*Prescottia lobata*.

OAKWOOD: June 18, 1926, Frison & Hayes, 1 ♂. WAUKEGAN: May 14, 1930, Frison & Ross, 2 ♀.

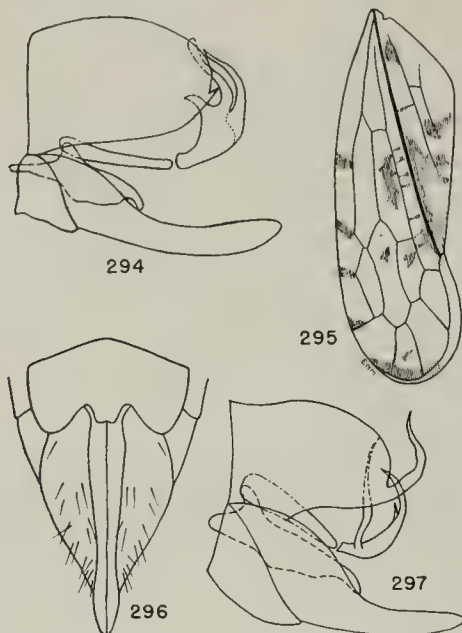


Fig. 294.—*Mesamia nigridorsum*, lateral aspect of male genitalia.

Fig. 295.—*Mesamia nigridorsum*, elytron.

Fig. 296.—*Platymetopius vitellinus*, female genitalia.

Fig. 297.—*Platymetopius vitellinus*, lateral aspect of male genitalia.

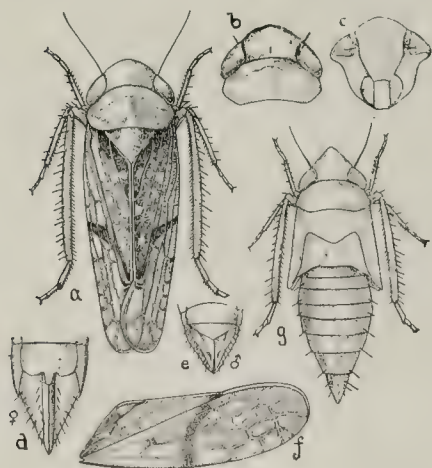


Fig. 298.—*Platymetopius vitellinus*: a, adult; b, head and pronotum; c, face; d, female genitalia; e, male genitalia; f, elytron; g, nymph. (From Osborn.)

2. *Platymetopius palliolatus* (Ball)

Eutettix palliolata Ball (1902a, p. 13).

Length 5–6 mm. Pale lemon yellow, tinged with greenish or brown. Pronotum, scutellum, and a narrow sutural stripe extending to apex of elytra dark brown; anterior portions of stripes often narrowly margined with white; brown stripe often contains smaller white spots. Face pale yellow, straight in lateral view. Vertex rather strongly produced and bluntly angled, about one and one-half times as wide between eyes at base as median length. Vertex flat, with a sharp margin.

Female seventh sternite truncate posteriorly, with a median produced blunt tooth notched at apex, tooth occupying the median fourth of segment and half as long as basal width. Male plates rather long, apices bluntly rounded. Styles gradually tapering from bases to blunt apices. Each pygofer with a spine arising ventrally at about the middle on either side and extending beyond apex. Aedeagus short, rather broad at base, narrowed to bifid apex, curved dorsally, then anteriorly.

This species is known only from Texas.

47. *JAPANANUS* Ball

Japananus Ball (1931c, p. 218).

Fig. 211. This genus is described as similar to *Platymetopius* in having the single cross nervure and the vermiculate markings. Vertex rather long and acute; elytra each with few or no veinlets to the costa. The latter character is probably the best one to use in separating it from the closely allied genera.

The only species known in this genus is an Oriental importation and occurs commonly upon maples in Illinois. Thus far in the United States, it is known to occur in the eastern part only.

1. *Japananus hyalinus* (Osborn)

Platymetopius hyalinus Osborn (1900d, p. 501).

Length of male 4.5 mm., female 5.5 mm. Face bright yellow, vertex, pronotum, and scutellum gray to green, tinged with bright yellow and smoky, often with pale longitudinal stripes on middle and from disc of vertex to eyes. Elytra hyaline, veins dark, a narrow, broken band of brownish spots

across anterior portion of each clavus, another across apex, and a third crossing apical portion of each elytron at apical crossveins.

Vertex in female more than twice as long as basal width between the eyes, deeply furrowed longitudinally. Male with vertex more blunt, about one and one-half times as long as basal width between the eyes, disc deeply depressed. Pronotum short and broad in both sexes, more than twice as wide as median length, eyes extending over anterior margin rather deeply on each side.

Female seventh sternite concavely produced for more than twice its length on posterior margin to form a long broad pointed tooth reaching two-thirds the length of pygofers. Male plate, fig. 291, long, triangular on basal half, then narrowed to form narrow attenuate tip, which is produced about the length of the basal half.

Illinois Records.—ALTON: July 19–21, 1932, Ross & Dozier, 11 ♂, 13 ♀; June 27, 1934, DeLong & Ross, 4 ♂. JACKSONVILLE: Aug. 23, 1943, 1 ♂, 1 ♀. MONTICELLO: Sept. 22, 1934, H. H. Ross, 1 ♀. OAK LAWN: in lamp globe, Aug. 22, 1934, 1 ♀. URBANA: Aug. 10, 1932, H. H. Ross, 3 ♀; Aug. 10, 1932, H. H. Knight, 1 ♂, 1 ♀; Sept. 7, 1934, Ross & Townsend, 3 ♂, 1 ♀; Aug. 28, 1934, Ross & Townsend, 3 ♀.

48. *SCAPHYTOPIUS* Ball

Scaphytopius Ball (1931c, p. 218).

Vertex flat, eyes large, deeply set into pronotum. Pronotum broader than head, venation regular, with two crossveins. Male genitalia with a single heavy portion that is bifid at apex.

Only one species, *elegans*, with three varieties, is known to occur in the United States. It is recorded from California, Arizona, and Florida.

1. *Scaphytopius elegans* (Van Duzee)

Platymetopius elegans Van Duzee (1890c, p. 94).

Length 4.5–5.0 mm. Pale brown, vertex margined with black anteriorly, a narrow pale median stripe at apex merging with a broad pale yellowish longitudinal stripe that extends from near apex of vertex across pronotum, scutellum, and each clavus of elytra to apex of clavus; stripe includes entire scutellum. Elytra brownish subhyaline, costal veins brown. Face dull yellow,

with a brown line above, leaving a narrow pale marginal band between the two parallel dark lines. Vertex blunt at apex, almost twice as long at middle as basal width between eyes at base.

Female seventh sternite rather broadly and roundedly produced on posterior margin. Male styles, fig. 241, with short thick apical processes that are curved outwardly. Aedeagus short and rather broad, with a pair of rather heavy divergent finger-like processes at apex.

This species is known only from Florida, Arizona, and California.

49. *CLOANTHANUS* Ball

Cloanthanus Ball (1931c, p. 219).

Fig. 299. Vertex flat, acutely angled, longer than basal width between eyes. Gena visible behind eyes. Pronotum broader than head. Elytral venation regular, two cross nervures between sectors, and numerous short reflexed veinlets to costa. Male genitalia with a dorsal portion and a pair of long ventral processes.

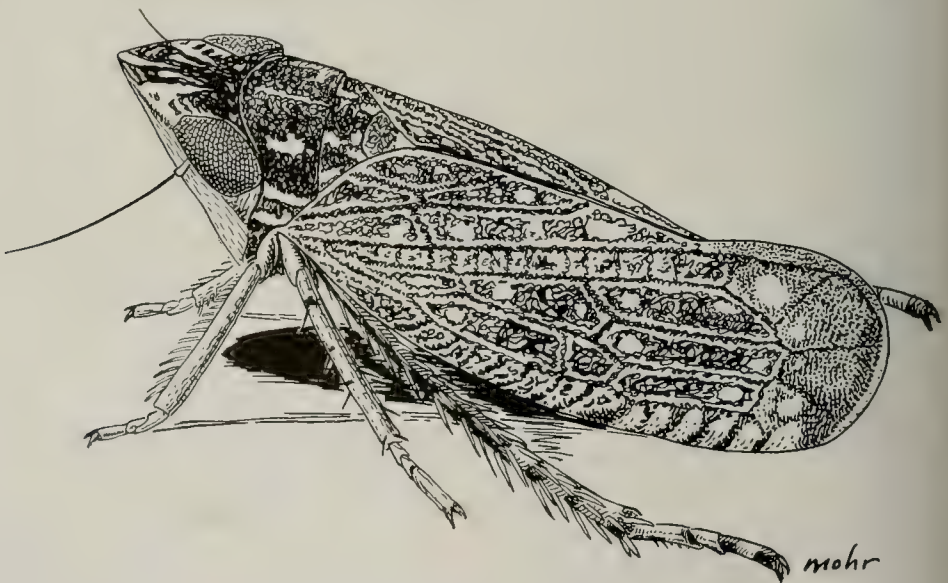
This genus includes almost all of the eastern species formerly placed under *Platymetopius*. DeLong (1943, 1945) and Hepner (1946) record about 85 species and subspecies as occurring in the United States. Thirteen species have been taken in Illinois, and several more may occur here.

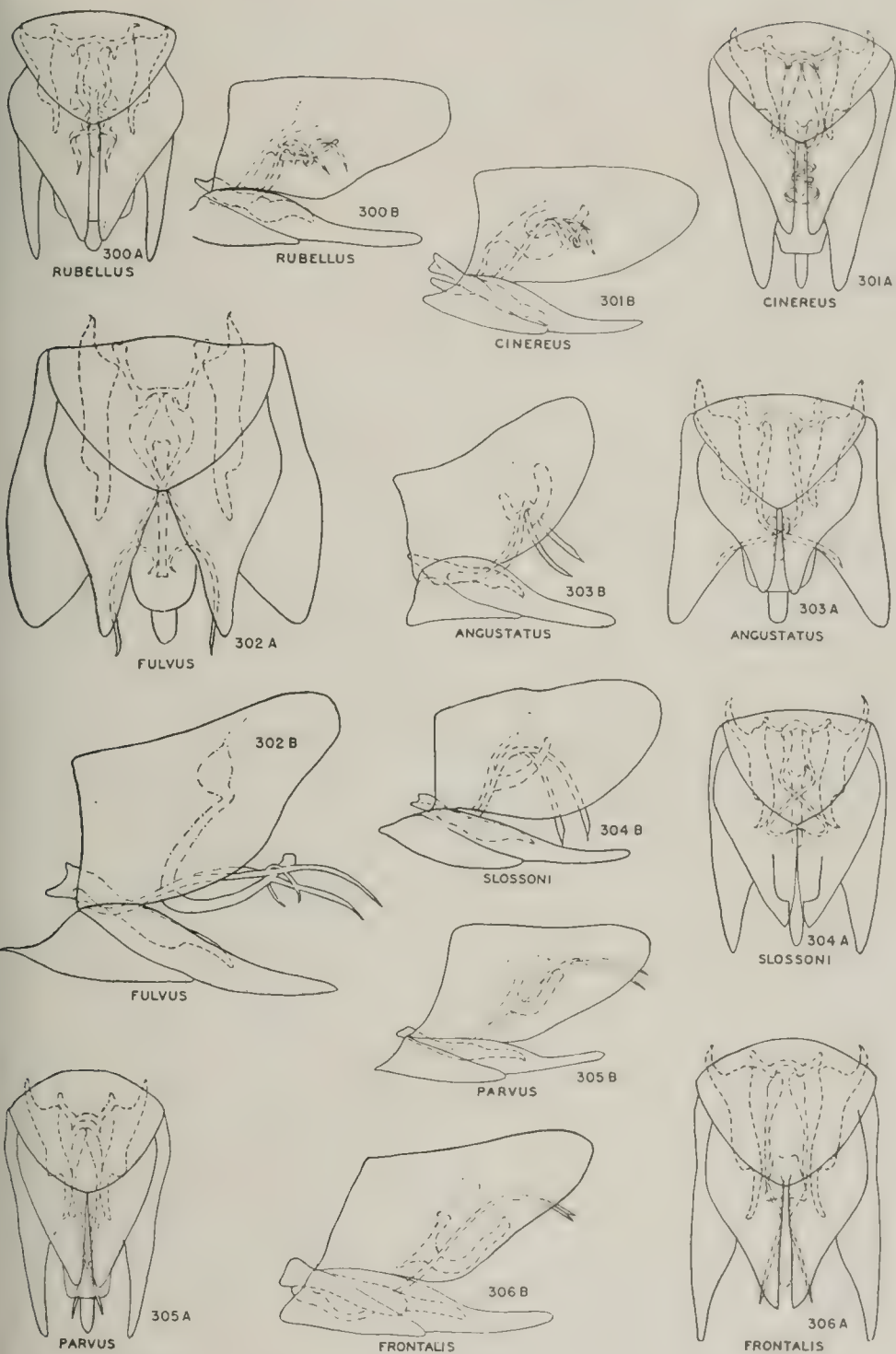
The structures of the male genitalia present the most reliable characters for distinguishing the species of this genus. The color characters will aid in the identification of females of some species, but they are not entirely reliable.

KEY TO SPECIES

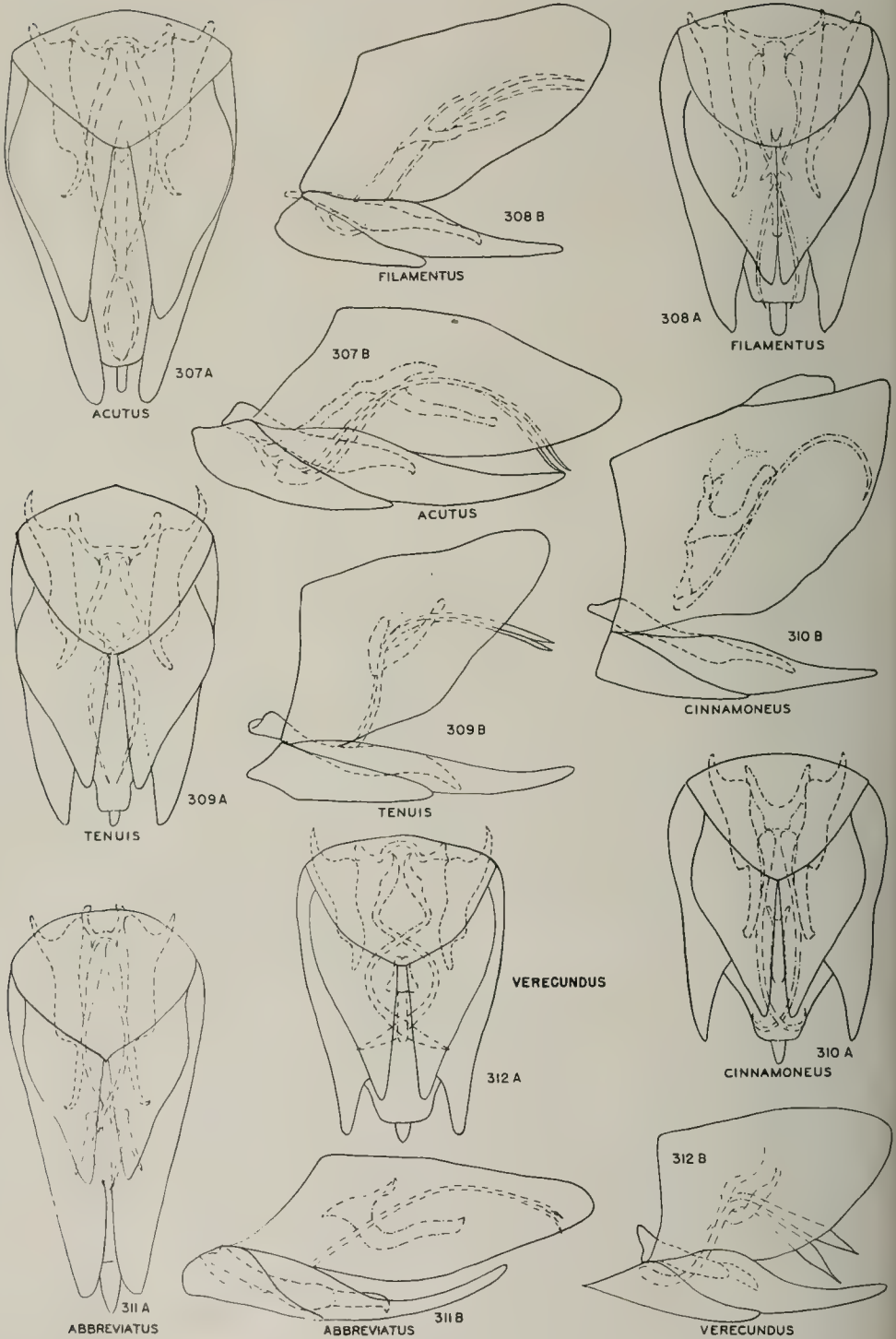
- 1. Males.....2
Females.....30
- 2. Long ventral paired processes of aedeagus slender to apexes, often coiled, curved, or branched but not broadened near apexes, as in fig. 300.....3
Ventral paired processes each broadened or blade-like just before apex, often bearing a dorsal spine, as in fig. 312.....15
- 3. Paired processes coiled around dorsal portion of aedeagus, as in fig. 301.....4
Paired processes extending toward caudal portion of pygofers, usually crossing each other and sometimes crossed over dorsal aedeagus portion but not coiled around it, as in fig. 302.....5
- 4. Vertex long, sharp; face brown; dorsal surface of body usually tinged with red.....18. *rubellus*

- Vertex shorter; face yellowish; dorsal surface of body cinereus, never brown or tinged with red **17. cinereus**
5. Paired aedeagus processes each bearing a distinct inner branch at about two-fifths the distance from apex, fig. 302. **6**
- Paired aedeagus processes not branched, as in fig. 303. **7**
6. Brownish fulvous, unmarked. **26. fulvus**
- Brown, with a black pronotum, anterior portion of scutellum often black. **27. collaris**
7. Ventral processes, fig. 303, crossed and bent over dorsal portion of aedeagus, then curved ventrally; color greenish brown. **16. angustatus**
- Ventral paired processes not bent over dorsal aedeagus, but extending caudally to apices of pygofer, as in fig. 305. **8**
8. Face yellow, often margined with brown. **9**
- Face irrorate with brown. **13**
9. Dorsal portion of aedeagus thick, rather heavy, and broadly rounded at base, as in fig. 306. **10**
- Dorsal portion of aedeagus more elongate, slender, and with basal curve more V-shaped and pointed at base, as in fig. 304. **11**
10. Black above, face bright yellow. **28. frontalis**
- Grayish green, tinged with brown. **23. parvus**
11. Vertex twice as long as basal width between eyes. **29. slossoni**
- Vertex more than half as wide between eyes at base as median length. **12**
12. Each pygofer, fig. 307, long and tapered to a narrow blunt apex; dorsal portion of aedeagus especially elongated. **19. acutus**
- Each pygofer shorter, more rounded; dorsal portion of aedeagus shorter, as in fig. 308. **13**
13. Each style, fig. 308, with long apex formed by the gradual narrowing of the outer margin beyond middle; dorsal portion of aedeagus long and sinuate. **20. filamentus**
- Each style, fig. 309, abruptly narrowed at three-fourths its length, apical processes short; dorsal portion of aedeagus straight and thicker at base. **25. tenuis**
14. Each pygofer, fig. 310, short, with a bluntly pointed apex on dorsal margin; ventral paired processes broadly curved ventrally and anteriorly at apices. **21. cinnamomeus**
- Each pygofer, fig. 311, long, tapered gradually to narrow blunt apex, greatly exceeding plates. **22. abbreviatus**
15. Blades of ventral aedeagus processes without spines on dorsal or inner surfaces, as in fig. 303. **16**
- Blades of ventral aedeagus processes bearing some kind of pointed spinelike structures on dorsal or inner surface, as in fig. 315. **18**
16. Blades scarcely widened on apical portion, fig. 303. **16. angustatus**
- Blades distinctly widened, as in figs. 312, 314. **17**
17. Face brown, vertex appearing banded transversely. **1. verecundus**
- Face yellow, with darker margins, vertex not appearing banded. **2. argutus**
18. Face and vertex pale; pronotum, scutellum, and elytra darker. **19**
- Vertex brown or black, with pale longitudinal markings. **20**
19. Face and vertex white; pronotum, scutellum, and elytra shiny black, with few pale spots or areoles. **14. bicolor**

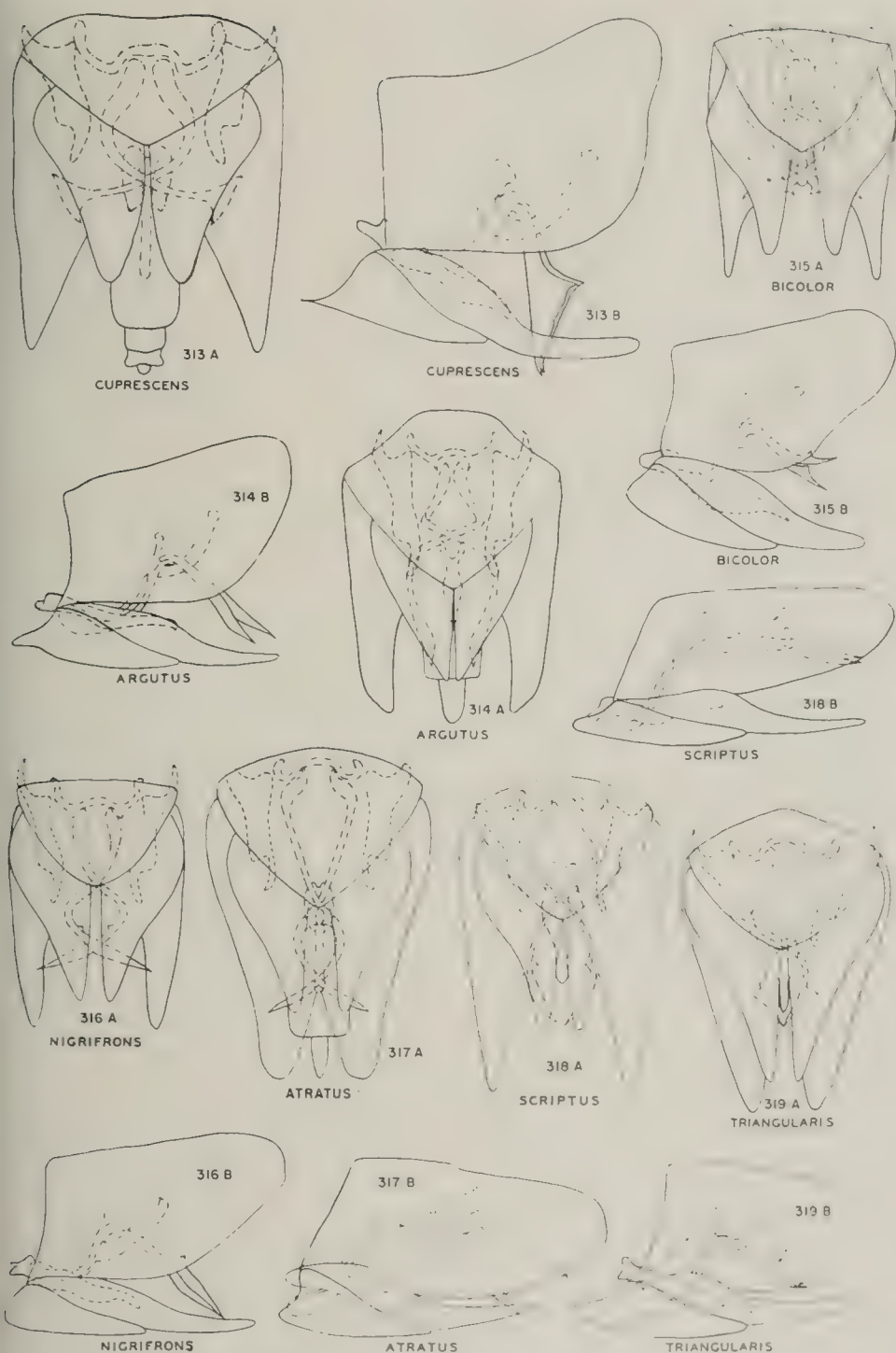
Fig. 299.—*Cloanthanus frontalis*.



Figs. 300-306.—*Cloanthanus*, male genitalia. A, ventral aspect; B, lateral aspect.



Figs. 307-312.—*Cloanthanus*, male genitalia. A, ventral aspect; B, lateral aspect.



Figs. 313-319.—*Cloanthanus*, male genitalia. A, ventral aspect; B, lateral aspect.

- Face and vertex dull yellow; pronotum irrorate with brown, elytra pale, with brownish irrorations, apex of each elytron pale. **13. dorsalis**
20. Face yellowish. 21
21. Face brown or black. 23
21. Vertex long and pointed; blades of aedeagus processes, fig. 313, forming large triangular plates at apex. **15. cuprescens**
- Vertex pointed but shorter; apical portions of processes formed into elongate blades, as in figs. 321, 324. 22
22. Blade of each aedeagus process, fig. 321, widened between spine and apex. **3. hastus**
- Blade of each aedeagus process, fig. 324, tapering from spine to apex. **4. lanceus**
23. Spine large, forming a triangle with apex, fig. 319. **12. triangularis**
- Spine smaller, at least one-fourth the distance from apex and not forming a triangular apex, as in fig. 317. 24
24. Blades narrow, spine almost one-half the distance from apex to base, as in fig. 317. 25
- Blades shorter, spine nearer apex, not more than one-third the distance from apex to base, as in fig. 322. 27
25. Vertex dark, with few pale markings; face almost black. **9. atratus**
- Vertex with pale markings, appearing transversely banded; face brown. 26
26. Spine conspicuous, each style with narrow apical processes about one-fifth the length of entire style, fig. 320. **10. magdalensis**
- Spine minute, each style with narrow apical processes about one-third the length of entire style, fig. 325. **11. vaccinium**
27. Vertex appearing banded or marked with pale areas; face pale brown or with brownish irrorations. 28
- Vertex dark brown to black, with few pale markings; face dark brown to black. 29
28. Vertex white, with brown markings; aedeagus blade, fig. 322, narrow, spine large, bent inwardly, slightly broadened between spine and apex. **7. varius**
- Vertex more brownish, with a banded appearance; blade, fig. 323, broadest at spine, concavely tapered on dorsal margin to sharp-pointed apex. **8. andromus**
29. Face black; aedeagus blade, fig. 316, narrow, about uniform in width between delicate spine and apex. **5. nigrifrons**
- Face dark brown; blade, fig. 318, broadest at blunt spine, from which it is tapered to sharp-pointed apex. **6. scriptus**
30. Face and vertex pale, unmarked; pronotum and elytra darker. 31
- Vertex not pale, unmarked. 32
31. Face and vertex white; pronotum, scutellum, and elytra shiny black, elytra with few pale markings. **14. bicolor**
- Face and vertex dull yellow; pronotum irrorate with brown, scutellum pale, elytra with pale brownish irrorations, each apex pale. **13. dorsalis**
32. Fulvous brown, pronotum and anterior portion of scutellum black. **27. collaris**
- Color black or brown, but not brown with black pronotum. 33
33. Color black above, face bright yellow. **28. frontalis**
- Color not black above, not with bright yellow face. 34
34. Face some shade of yellow, often margined with brown. 35
- Face pale to dark brown or black. 43
35. Vertex long, sharp pointed, usually less than two-thirds as wide between eyes at base as median length. 36
- Vertex shorter, often sharply angled, usually more than two-thirds as wide between eyes as median length. 38
36. Color usually dark brown, tinged with red above and on face. **18. rubellus**
- Cuprescent or pale brownish, not tinged with red. 37
37. Pale brown. Known only from Florida. **29. slossoni**
- Copper colored. Known only from the northeastern United States. **15. cuprescens**
38. Gray, tinged with green above and on face. **16. angustatus**
- Not tinged with green. 39
39. Gray in color. 40
- Brown or fulvous in color. 41
40. Length 4.0 mm. **17. cinereus**
- Length 3.5 mm. **23. parvus**
41. Fulvous brown in color, with few pale or areolar spots except at apical cross-veins. **26. fulvus**
- Brown, with numerous pale and areolar spots throughout the elytra. 42
42. Vertex sharply pointed, heavily infuscated with brown. **2. argutus**
- Vertex usually blunter, pale brown, less heavily infuscated. **19. acutus, 20. filamentus, 25. tenuis**
43. Vertex twice as long as basal width between eyes, banded. **1. verecundus**
- Vertex shorter, not less than two-thirds as wide between eyes as median length. 44
44. Vertex appearing banded transversely. 45
- Vertex dark in color or without bands. 47
45. Vertex pale, with dark markings, pale areas large and conspicuous. **7. varius**
- Vertex darker, pale areas small. 46
46. Band on vertex formed by a V-shaped lighter spot on either side of vertex anterior to eyes. Known only from Florida. **8. andromus**
- Band usually less conspicuous, without V-shaped pale areas at sides of vertex. **10. magdalensis, 11. vaccinium**
47. Vertex with a sharp-pointed produced apex. 48
- Vertex less sharply produced. 49
48. Face pale brown. **21. cinnamomeus**
- Face dark brown. **22. abbreviatus**
49. Elytra shiny black, with few pale or areolar spots except on apical cross-veins. **5. nigrifrons**

Elytra black or brown, mottled with pale spots or areoles ⁵⁰

50. Brown in color, with white longitudinal marks on vertex.....6. *scriptus*
 Black in color, vertex marked with fewer light lines or spots.....9. *atratus*

1. *Cloanthanus verecundus* (Van Duzee)

Platymetopius verecundus Van Duzee (1910, p. 227).

Length 3.5–4.0 mm. Vertex rather sharply angled, more than twice as long at middle as basal width between eyes. Dark brown, tinged with orange, a broken pale band across vertex before anterior margins of eyes, and pale spots at base of vertex. Pronotum marked with five longitudinal lines. Scutellum orange. Elytra pale, with rather sparse reticulations, leaving many pale areas and areolar spots; veins brown. Face rather heavily irrorate with brown.

Female seventh sternite roundedly produced on posterior margin. Male plates almost as long as pygofers, gradually narrowed to blunt apices. Each style with short narrow finger-like apex produced on inner margin. Aedeagus, fig. 312, with a rather narrow dorsal portion that is narrowed on apical fourth and curved upward at base; ventral paired processes long and curved, with widened spearlike blades on apical third; spines absent.

This species is known only from Florida and the southeastern states.

2. *Cloanthanus argutus* DeLong

Cloanthanus argutus DeLong (1945, p. 24).

Length 4 mm. In form and general appearance resembling *hastus* but smaller and with distinctive male genitalia. Vertex rather sharply angled, a little more than half as wide as median length, one-fourth longer than pronotum. Dorsum dark brown, with pale markings. Vertex with conspicuous pale longitudinal vittae. Pronotum with several pale punctate spots. Elytra with brown veins and irrorate markings, leaving pale areas throughout and several round pale areolar spots. Face dull yellow below, brown above.

Female seventh sternite roundedly produced on posterior margin. Male plates shorter than pygofers, gradually sloping to bluntly pointed apices. Each style, fig. 314, narrowed somewhat at about three-fourths its length, apex rather broad, blunt, and

produced about one-fourth the length of style; dorsal portion of style medium in length, a little narrower at apex than base. Ventral paired processes of aedeagus with apical third widened to form a narrow blade that does not bear a spine on dorsal margin. Each pygofer broadly rounded at apex.

This species is recorded only from Georgia.

3. *Cloanthanus hastus* DeLong

Cloanthanus hastus DeLong (1945, p. 24).

Length 4.5 mm. Resembling *acutus* in form and general appearance but with a pale brown face. Vertex elongate, sharply angled, decidedly more than half as wide between eyes at base as median length. Dorsum rather dark brown, vertex with median apical vitta and slender elongate lines pale. Pronotum with five longitudinal vittae. Elytra rather heavily irrorate with brown, veins brown; many pale areas and areolar spots. Face pale brown.

Female seventh sternite roundedly produced on posterior margin. Male plates almost as long as pygofers, gradually narrowed to blunt apices. Each style, fig. 321, elongate, with abruptly narrowed finger-like process on inner margin of apex, the process almost one-third the length of the style. Aedeagus with the dorsal portion rather short and thickened and bluntly pointed at base; paired ventral processes each long and narrow to apical fifth, then widened to form spearlike blade that is pointed at apex, each blade bearing a small spine on the upper surface about one-fourth the distance from apex.

This species has been collected in Wisconsin, Ohio, Missouri, and Illinois.

Illinois Records.—Many males and females, taken May 18 to October 2, are from Alton, Cave in Rock, Centralia, Des Plaines, Dixon, Dolson, Eichorn, Fairfield, Galena, Geff, Herod, Keithsburg, Mahomet, Ozark, Pulaski, Vienna, Wauconda, and White Pines Forest State Park.

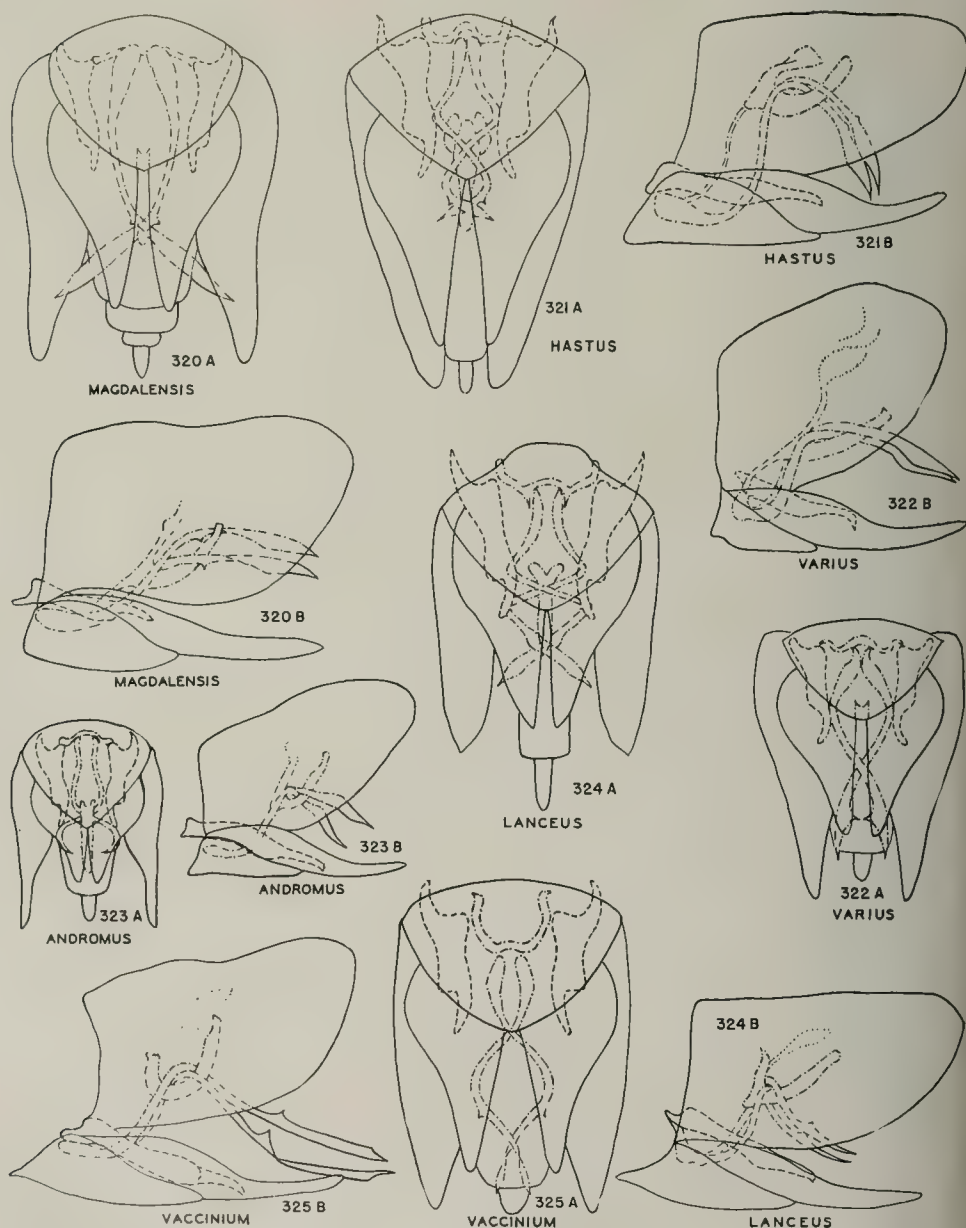
4. *Cloanthanus lanceus* DeLong

Cloanthanus lanceus DeLong (1945, p. 26).

Length 4 mm. Small, sharp headed, resembling *argutus* in general appearance but with distinctive genitalia. Vertex sharply pointed, almost half as wide between eyes at base as median length. Vertex pale

brownish, with longitudinal pale markings. Pronotum dark brown, with five pale longitudinal vittae. Scutellum paler than pronotum, apex pale brown. Elytra finely irrorate with dark brown, only a few pale spots visible and with few areolar spots. Face uniform dull yellow to pale brown, without infuscation above.

Female seventh sternite roundedly produced on posterior margin. Male style, fig. 324, notched on outer margin at about three-fourths its length, forming a finger-like process that is produced to form the apex of the style. Dorsal portion of the aedeagus medium in length, with a sharp bend at base; ventral paired processes curved



Figs. 320-325.—*Cloanthanus*, male genitalia. A, ventral aspect; B, lateral aspect.

through the bend in the dorsal portion, their apexes broadened to form bladelike structures that extend about one-fourth the length of process and bear a pointed heel on upper inner angle of blade.

This species has not been taken in Illinois. It was described from Georgia.

5. *Cloanthanus nigrifrons* (DeLong)

Platymetopius frontalis var. *nigrifrons* DeLong (1923, p. 103).

Length 4 mm. Vertex short, bluntly angled, three-fourths as wide between eyes at base as median length. Black, vertex marked with white elongate spots. Pronotum with faint traces of white. Elytra black, shiny, with few white markings represented only by white areolar spots along commissural line of each clavus, and before and posterior to the apical crossveins. Face heavily irrorate with dark brown or black.

Female seventh sternite roundedly produced on posterior margin. Male plates almost as long as pygofers, gradually narrowed and rather blunt at apexes. Each style, fig. 316, rather narrow, apical fourth abruptly narrowed and produced on inner margin to form a long slender finger-like process. Dorsal portion of aedeagus rather long and thick, with apical fifth narrowed; ventral paired processes long and slender to apical fourth, which is broadened to form spearlike blades with sharp-pointed apexes and a rather prominent spine on upper margin almost one-third the distance from apex.

This black-faced species was described from Connecticut.

6. *Cloanthanus scriptus* (Ball)

Platymetopius scriptus Ball (1909b, p. 165).

Length 4 mm. Vertex short, about three-fourths as wide between eyes at base as median length. Dark brown, vertex with a median white apical longitudinal vitta, a white one along margin next to each eye, a pair of discal white spots and small white spots at base. Pronotum marked with five longitudinal vittae. Scutellum with white spots on disc, basal angles tan. Elytra irrorate with brown, veins brown, pale areas throughout, and each elytron with round white areolar spots on apical portion; numerous brown costal veinlets. Face heavily irrorate with brown.

Female seventh sternite roundedly produced posteriorly. Male plates broad at bases and with narrow rounded apexes. Each style, fig. 318, elongate, apical fourth produced into a slender finger-like apex on inner margin. Aedeagus with dorsal portion long, narrowed just before apex, pointed at base, with an upturned spur; ventral paired pieces long and slender, with widened blades at apex that have barblike spines dorsally about one-third the distance from apex.

This species occurs in the middle western states and has been collected from several localities in Illinois.

Illinois Records.—Many males and females, collected May 18 to October 3, are from Anvil Rock, Apple River Canyon State Park, Elizabethtown, Marshall, Monticello, Ozark, Starved Rock State Park, Warren, and White Heath.

7. *Cloanthanus varius* DeLong

Cloanthanus varius DeLong (1945, p. 26).

Length 4 mm. Resembling *magdalensis* in form but with vertex white, mottled with brown, and with distinct male aedeagus. Vertex short, blunt, more than three-fourths as wide between eyes as median length. Vertex with a marginal bar on either side at apex, and longitudinal brown vittae at apex and between eyes, giving it a transversely banded appearance. Pronotum dark brown. Scutellum tawny, with white spots on median portion. Elytra brown, heavily irrorate, with pale areolar spots. Face heavily irrorate with brown.

Female seventh sternite roundedly produced on posterior margin. Male pygofers decidedly longer than plates. Apical third of each style, fig. 322, narrowed to a slender curved finger-like process. Dorsal portion of aedeagus rather long, constricted just before apex; each of ventral paired processes broadened on apical fourth to form a blade; spine on upper margin about one-third the distance from apex and bent inwardly on dorsal margin.

This species is known only from Illinois.

Illinois Records.—DIXON SPRINGS: July 9, 1935, DeLong & Ross, 1♀. ELIZABETHTOWN: June 25, 1932, Ross, Dozier, & Park, 1♀. MARSHALL: Sept. 27, 1935, Frison & Ross, 1♀. MONTICELLO: June 11, 1934, Frison & DeLong, 1♂, 4♀. STARVED ROCK STATE PARK: July 14, 1932, Dozier

& Park, 1 ♀. WHITE PINES FOREST STATE PARK: July 12, 1934, DeLong & Ross, 1 ♀.

8. *Cloanthanus andromus* (Ball)

Nasutoideus andromus Ball (1931c, p. 221).

Length 4 mm. Vertex short, almost three-fourths as wide between eyes at base as median length. Vertex tawny, with short longitudinal vittae so arranged as to form a broken pale transverse band before anterior margins of eyes, and a narrower band at base. Pronotum brown, scutellum tawny. Elytra with veins brown, with sparse brown irrorations; costal veinlets brown, with numerous white areolar spots throughout the surfaces of elytra. Face pale brown.

Female seventh sternite roundedly produced on posterior margin. Male styles, fig. 323, each with a narrow apical finger-like process that is about one-fourth the length of style. Dorsal portion of aedeagus slender and elongate, curved at base, each of ventral paired processes with apical third broadened into blade that is sharp pointed; apex of each blade dorsally pointed.

This species is known only from Florida, but may occur in states farther north.

9. *Cloanthanus atratus* DeLong

Cloanthanus atratus DeLong (1945, p. 27).

Length 4 mm. In form and general appearance similar to *vaccinium* but with narrower aedeagus blades. Vertex about three-fourths as wide at base as median length. Color brown, vertex with few pale markings, short apical median vitta conspicuous. Elytra brown, with brown veins and scattered brown irrorations, leaving many pale areas and white areolar spots. Face heavily irrorate with brown. Male plates decidedly shorter than pygofers. Each style, fig. 317, with short narrow apical process that is about one-fourth the length of style. Dorsal portion of aedeagus broad at base, narrowed on apical fourth; each of ventral paired processes with apical third widened to form narrow blade, a small spine on dorsal margin more than one-third the distance from apex.

This species is known only from Illinois.

Illinois Records.—OREGON: Castle Rock, June 30, 1935, DeLong & Ross, 2 ♂. VOLO: in bog, Aug. 24, 1935, DeLong & Ross, 1 ♂.

10. *Cloanthanus magdalensis* (Provancher)

Platymetopius magdalensis Provancher (1889, p. 275).

Platymetopius obscurus Osborn (1905a, p. 274).

Length 4.5 mm. In form and general appearance resembling *acutus* but with banded vertex and brown face. Vertex short and broad, more than two-thirds as wide between eyes as median length; brown, short white vittae arranged to form a broken transverse band before anterior margins of the eyes, and a pale band at base. Pronotum dark brown, scutellum pale brown. Elytra brownish subhyaline, with darker irrorations and with numerous pale areas and areolar spots. Face brownish irrorate. Male plates not reaching apexes of pygofers, plates gradually narrowed to bluntly pointed apexes. Each style, fig. 320, narrow, with short blunt narrowed finger-like apex that is about one-fifth the length of the style. Dorsal portion of aedeagus gradually narrowed from a rather thickened base to narrow apex; ventral paired processes each long and narrow to apical third, which is widened, bladelike, and with a prominent dorsal spine almost half the distance from apex.

This species is northeastern in distribution and occurs on species of *Vaccinium*.

11. *Cloanthanus vaccinium* DeLong

Cloanthanus vaccinium DeLong (1945, p. 27).

Length 4.5 mm. Short, broad headed, closely related to *magdalensis* but with some differences in the male genitalia. Vertex three-fourths as wide between eyes at base as median length; brown, appearing banded with conspicuous elongate white vittae at middle of apex and base. Elytra dull brown, with scattered darker brown irrorations; veins brown; white areolar spots along commissure of each clavus and in base of each apical and apex of each anteapical cell. Face heavily irrorate with brown. Each male style, fig. 325, abruptly narrowed at two-thirds its length, apical third finger-like and curving slightly outward. Dorsal portion of aedeagus broadly curved at base, narrowed on anterior margin at apex; ventral paired processes with apical third broadened into bladelike portions; a large conspicuous

spine on dorsal margin more than one-third the distance from apex.

This species is considered a synonym of *magdalensis* by Hepner (1946), but I believe that for the present it is advisable to consider the two species as distinct, based on the characteristics given in the key. More material from various parts of the range of the two species will ultimately solve this problem.

This species is known only from Illinois, and was taken on *Vaccinium* in bogs.

Illinois Records.—DIXON: Sept. 17, 1935, DeLong & Ross, 1 ♀. GRAND DETOUR: July 12, 1934, DeLong & Ross, 2 ♀. VOLO: July 27, 1934, DeLong & Ross, 1 ♀; in bog, Aug. 24, 1935, DeLong & Ross, 3 ♀.

12. *Cloanthanus triangularis* DeLong

Cloanthanus triangularis DeLong (1945, p. 27).

Length 4 mm. Resembling *magdalensis* but with a more pointed vertex and distinctive male genitalia. Vertex sharply angled, almost twice as long at middle as basal width between eyes; dark brown, with slender pale vittae. Elytra pale brown, irrorate with darker brown, leaving many pale areas and areolar spots; veins brown. Face heavily irrorate with brown. Male plates almost as long as pygofer. Each style, fig. 319, with apical third narrowed and produced as finger-like process. Dorsal portion of aedeagus rather short, narrowed to blunt apex; ventral paired processes enlarged near apices to form large pointed spines on upper surface, spines about one-sixth the distance from apex.

This species has been collected only in Illinois.

Illinois Records.—EICHORN: Hicks Branch, June 13, 1934, DeLong & Ross, 1 ♀. NORRIS CITY: June 17, 1934, DeLong & Ross, 1 ♀. SHAWNEETOWN: June 14, 1934, Ross & DeLong, 11 ♂, 19 ♀; June 27, 1936, DeLong & Mohr, 1 ♀.

13. *Cloanthanus dorsalis* (Ball)

Platymetopius frontalis var. *dorsalis* Ball (1909b, p. 164).

Length 4.5 mm. Vertex bluntly angled, three-fourths as wide between eyes at base as median length. Vertex, face, and venter pale yellow. Pronotum irrorate with brown.

Scutellum pale, with brown basal angles. Elytra pale, with brownish irrorations except on apical portions; apical half of each clavus pale, white areolar spots along commissural line and on corium and along apical crossveins; costal veinlets brown.

This species was described from Kansas. In Illinois three specimens have been taken that are quite similar to the type specimen and have been referred to this species. The male is unknown.

Illinois Records.—DOLSON: July 24, 1936, DeLong & Mohr, 1 ♀. EICHORN: Hicks Branch, June 13, 1934, DeLong & Ross, 1 ♀. ST. ANNE: July 20, 1934, DeLong & Ross, 1 ♀.

14. *Cloanthanus bicolor* (DeLong)

Platymetopius bicolor DeLong (1916, p. 38).

Length 4 mm. Vertex bluntly angled in the male, more than two-thirds as wide between eyes at base as median length. Vertex pale yellow, pronotum shiny black, scutellum black, with a white margin on apical angle. Elytra shiny black, without areoles except on anterior apical cells; apical border of each elytron white margined. Face and thorax below pale yellow, unmarked. Each male plate broad at base, narrow at apex, and rounded. Each style, fig. 315, with rather short finger-like process, which is narrowed and curved outwardly at apex. Dorsal process of aedeagus rather long, constricted just before rounded apex, and curved dorsally at base; ventral paired processes curved with half of a spearhead blade bearing a barblike spine at base about one-fourth the distance from apex.

This strikingly colored species is known only from one male collected in Tennessee.

15. *Cloanthanus cuprescens* (Osborn)

Platymetopius cuprescens Osborn (1905b, p. 517).

Length 5.5 mm. Vertex appearing sharp pointed, three-fifths as wide at base between eyes as median length. Brown, vertex with a short conspicuous pale vitta at apex. Pronotum with five pale longitudinal vittae. Elytra pale, irrorate with brown, having round white areoles and pale areas throughout the elytral surfaces. Face dull yellow, with a pale transverse band below apex, area darker between this pale band and margin

of vertex. Male plates rather short, with blunt apices. Dorsal process of aedeagus, fig. 313, with a rather long ventral portion, curved upward at base; a pair of ventral processes extending from base, curved around dorsal portion, then protruding to form in apical region broad triangular blades, each comprising about one-fourth of the entire ventral process.

This is the most common of the northern long-headed species of the genus.

Illinois Records.—Many males and females, taken May 27 to October 3, are from Alton, Antioch, Apple River Canyon State Park, Cave in Rock, Centralia, Dixon, Dolson, Dubois, Eichorn, Elizabethtown, Evergreen Park, Galena, Geff, Gibsonia, Grand Detour, Havana, High Knob, Jonesboro, Keithsburg, Mahomet, Monticello, Oregon, Palos Park, Pike, St. Anne, Vienna, Volo, White Pines Forest State Park, and Wolf Lake.

16. *Cloanthanus angustatus* (Osborn)

Platymetopius angustatus Osborn (1905b, p. 518).

Length 4 mm. Vertex in male bluntly pointed, about two-thirds as wide between eyes as median length, with longitudinal pale vittae. Pronotum irrorate with brown; scutellum tan. Elytra greenish-brown subhyaline, without areolar spots except before and just posterior to apical crossveins; posterior costal and apical veinlets broadly brown. Face tawny, male plates rather short, with narrow rounded apices. Each style, fig. 303, with an abruptly narrowed, short, finger-like process on inner margin, about one-fifth the length of style. Dorsal process of aedeagus rather short and thick; paired ventral processes long and slender, curved about the dorsal process, and with very narrow scarcely widened blades.

This species has been recorded from New York and Missouri, and has been collected on pine in coniferous forests.

17. *Cloanthanus cinereus* (Osborn & Ball)

Platymetopius cinereus Osborn & Ball (1897, p. 193).

Length 4 mm. Vertex rather short, two-thirds as wide as median length. Dorsum appearing greenish gray, with three con-

spicuous white longitudinal vittae on vertex. Pronotum with five conspicuous pale longitudinal vittae. Elytra light in color, with greenish-gray veins and sparse irrorations, veins on apical portion darker; large areas and areolar spots white. Face dull yellow. Each male style, fig. 301, with apical third narrowed and produced into a finger-like apex on inner margin. Dorsal portion of aedeagus rather broad at base, narrowed to about half its basal width at apex; ventral paired processes long, slender, and coiled around the dorsal portion of aedeagus.

This is the common prairie form of the genus and is found abundantly on the Illinois prairies. It has been recorded from the southeastern United States and from the Middle West.

Illinois Records.—Many males and females, taken from June 12 to October 2, are from Alsip, Amboy, Carman, Cave in Rock, Des Plaines, Elizabeth, Evergreen Park, Fairfield, Fulton, Grand Detour, Gulfport, Hanover, Kampsville, Mokena, Oak Lawn, Oquawka, Oregon, Palos Park, Port Byron, Putnam, St. Anne, Spring Valley, Urbana, Watson, and Zion.

18. *Cloanthanus rubellus* (Sanders & DeLong)

Platymetopius rubellus Sanders & DeLong (1919, p. 231).

Length 4.0–4.5 mm. Vertex strongly produced and sharply angled, less than two-thirds as wide between eyes at base as median length. Dorsum reddish brown, tinged with dark red. Vertex with a pale median apical vitta, and a pale vitta on either side of median vitta. Pronotum with five pale longitudinal vittae. Scutellum tan. Elytra brownish subhyaline, with darker irrorations, costal veinlets on apical half of each elytron brown margined; white areolar spots on apical portion and along commissural line of clavus. Face tawny, tinged with red. Male plates broad at base, rather long, and extending almost to tips of pygofers. Apical third of each style, fig. 300, narrow, finger-like, and produced almost straight on inner margin. Aedeagus with a long slender dorsal process and a pair of long slender processes that are usually coiled around the dorsal process.

The sharp-pointed vertex and reddish color will usually separate this species, which

has been found only on the East Coast of the United States, from closely related forms.

19. *Cloanthanus acutus* (Say)

Jassus acutus Say (1831, p. 306).

Length 4.5 mm. Vertex produced rather sharply, almost two-thirds as wide between eyes at base as median length. Dorsum brown, vertex with median pale vitta at apex, and conspicuous pale vitta on disc. Pronotum dark brown, scutellum tawny. Elytra pale, with scattered dark brown irrorations, leaving many pale spots and areolar spots. Face yellow, heavily infuscated with brown above the white line and at sides. Male pygofers one-fourth longer than plates. Each style, fig. 307, with apical third abruptly narrowed and produced as a slender finger-like process that curves outwardly. Dorsal portion of aedeagus with a long slender ventral process that is sinuate and tapered to apex, the latter slightly enlarged; ventral paired processes long and narrowed to apices. Each pygofer long, narrowed to a blunt produced apex.

A common yellow-faced species, *acutus* is transcontinental in distribution.

Illinois Records.—Many males and females, taken from May 7 to September 24, are from Adair, Alton, Amboy, Antioch, Apple River Canyon State Park, Aurora, Bushnell, Cave in Rock, Chester, Cypress, Danville, Des Plaines, Dixon, Dolson, Dubois, Elizabethtown, Elgin, Evergreen Park, Fern Cliff, Fox Lake, Galena, Geff, Golconda, Grand Detour, Grays Lake, Gulfport, Hanover, Hardin, Harrisburg, Havana, Justice, Kankakee, Karnak, Keithsburg, Lincoln, Mason City, Mound City, Mounds, Muncie, Niota, Normal, Oak Lawn, Oakwood, Ogden, Onarga, Oregon, Ozark, Pecatonica, Princeton, Pulaski, Putnam, Quincy, Round Lake, St. Anne, Shawneetown, Sparta, Starved Rock State Park, Urbana, Vandalia, Vienna, Virginia, Volo, Warren, Waukegan, Wolf Lake, and Zion.

20. *Cloanthanus filamentus* DeLong

Cloanthanus filamentus DeLong (1945, p. 22).

Length 5 mm. Resembling *acutus* in form and general appearance, but paler in color and with a shorter dorsal aedeagus in male

and blunter pygofers. Vertex two-thirds as wide between eyes at base as median length. Dorsum light brown, with three pale vittae on anterior portion of body. Pronotum with the usual pale vittae. Apical half of scutellum pale. Elytra rather sparsely irrorate with pale brown so that many areolar spots and pale areas are seen throughout the surface. Face yellow, with brown margin above. Each male style, fig. 308, narrow, gradually narrowed just beyond middle to narrow curved apical process that is more than one-third the length of the style. Dorsal portion of aedeagus with an elongated narrow process that is shorter than in *acutus*. Ventral paired processes long, slender, extending almost to apex of pygofers. Pygofers more blunt at apices than in *acutus*.

This species was described from Pennsylvania and has been taken at several localities in Illinois.

Illinois Records.—AMBOY: May 21, 1917, 1♂; Aug. 8, 1934, DeLong & Ross, 1♂. DES PLAINES: Sept. 18, 1935, DeLong & Ross, 3♂. JUSTICE: July 23, 1937, Mohr & Burks, 1♀. KANKAKEE: Aug. 8, 1935, Ross & DeLong, 1♂. MOUNDS: May 23, 1932, H. L. Dozier, 1♂. OAK LAWN: sand prairie, July 27, 1934, DeLong & Ross, 1♂. OAKWOOD: Aug. 17, 1934, DeLong & Ross, 1♂. VOLO: July 16, 1935, DeLong & Ross, 1♂.

21. *Cloanthanus cinnamoneus* (Osborn)

Platymetopius magdalensis var. *cinnamoneus* Osborn (1915, p. 114).

Length 4 mm. Resembling *acutus* in form and general appearance but with face pale brown and with distinctive genitalia. Vertex bluntly angled, about two-thirds as wide between eyes at base as median length. Vertex, pronotum and scutellum cinnamon brown, with pale elongate lines and vittae. Elytra pale, with brown veins and rather heavy brown irrorations having numerous pale spots and areoles; costal veinlets broadly brown. Face irrorate with pale brown. Each male style, fig. 310, narrowed just beyond middle, apical half forming a long rather thick finger-like process. Dorsal portion of aedeagus rather short, apex slightly enlarged; ventral paired processes long, slender, apices curved ventrally and anteriorly.

This species has been taken only in

Canada, Maine, and other northern states bordering Canada. It is unique in genital characters.

22. *Cloanthanus abbreviatus* (DeLong)

Platymetopius abbreviatus DeLong (1916, p. 39).

Length 4 mm. Resembling *acutus* in form and appearance but with a brown face. Vertex bluntly angled, a little more than half as wide at base as median length. Vertex brown, with whitish longitudinal vittae. Pronotum dark brown, with five pale longitudinal vittae; scutellum paler. Elytra pale, with brown veins and rather sparse reticulations, leaving many white areas and areolar spots; numerous costal veins brown. Face marked with pale brownish irrorations. Male plates about two-thirds as long as pygofers. Each style, fig. 311, abruptly narrowed at less than two-thirds its length and produced as a long slender process that is curved or hooked at apex. Dorsal portion of aedeagus broadly curved at base, rather thick throughout its length, and sinuate, the apex pointed on inner margin; ventral paired processes long and narrow. Pygofers long, tapered to bluntly pointed apices.

This species was originally described from two female specimens from Tennessee. Additional specimens, including males, have since been taken in Wisconsin and Illinois.

Illinois Records.—AMBOY: Aug. 8, 1934, DeLong & Ross, 1 ♂. CAVE IN ROCK: Oct. 2, 1934, Ross, 2 ♂. EICHORN: Hicks Branch, June 13, 1934, DeLong & Ross, 2 ♀. OREGON: June 21, 1917, 1 ♂; Aug. 23, 1935, DeLong & Ross, 4 ♂, 4 ♀. ST. ANNE: Aug. 21, 1934, DeLong & Ross, 1 ♂; Aug. 4, 1936, Frison & Burks, 1 ♂. WOLF LAKE: July 30, 1934, DeLong & Mohr, 4 ♂.

23. *Cloanthanus parvus* (Lathrop)

Platymetopius parvus Lathrop (1917, p. 122).
Platymoideus ovideus Ball (1931c, p. 227).

Length 3.5 mm. Small, resembling *cinereus* in color and general appearance. Vertex blunt at apex, slightly more than half as wide between eyes at base as median length. Dorsum pale, marked with brown. Vertex completely lined with pale longitudinal vittae. Pronotum with brown reticulations and five conspicuous pale longitudinal vittae. Scutellum tawny. Elytra pale, marked with brown veins and sparse reticu-

lations; apex of each smoky, costal veinlets brown, numerous white spots and reticulations throughout. Face bright yellow, darker above. Each male style, fig. 305, abruptly narrowed at about two-thirds its length, apical third narrow and produced into a long finger-like process. Dorsal portion of aedeagus short and rather thick, broadly rounded at base; ventral paired processes long and slender, reaching almost to apices of pygofers.

This relatively minute species has been collected only in the southeastern United States.

24. *Cloanthanus parvus* var. *niger* DeLong

Cloanthanus parvus var. *niger* DeLong (1945, p. 27).

Length 3.5 mm. Resembling *parvus* in size and general appearance, but darker in color and with shorter and blunter vertex. Dark brown, vertex heavily irrorate with a few pale longitudinal markings. Pronotum with five pale vittae. Scutellum paler. Elytra irrorate with brown, leaving many pale spots and white areoles. Face pale brownish. Male genitalia similar to those of *parvus*. The dorsal portion of the aedeagus short, rather thick, broadly rounded at base; the ventral paired processes slender throughout.

Known only from Alabama, this variety appears to be distinct from typical *parvus* in general appearance.

25. *Cloanthanus tenuis* DeLong

Cloanthanus tenuis DeLong (1945, p. 24).

Length 4.5 mm. Resembling *acutus* in form and general appearance but with a shorter basally rounded dorsal process of the aedeagus. Vertex a little more than half as wide between eyes at base as median length. Pale brown, vertex with pale longitudinal vittae, especially on apical portion. Pronotum darker on disc, scutellum with apical portion orange yellow. Elytra marked with pale brownish irrorations, leaving many pale areas and areolar spots. Face yellow, with a brown border above.

Each male style, fig. 309, with short finger-like process at apex, about one-fifth the length of the style. Dorsal portion of aedeagus medium in length, narrow, and with base sharply curved; ventral paired

processes of aedeagus long and slender, reaching to apexes of pygofer.

Described from South Dakota and Utah, this species has not been collected in Illinois.

26. *Cloanthanus fulvus* (Osborn)

Platymetopius fulvus Osborn (1905b, p. 519).

Length 4.5 mm. Vertex bluntly angled, in male less than two-thirds as wide between eyes at base as median length. Dorsum brownish fulvus, vertex paler, with three faint longitudinal vittae. Scutellum pale, lateral angles brown. Elytra with pale areoles before and caudad to apical cross-veins, apical veinlets broadly embrowned. Face dull yellowish, without darker margins. Male styles, fig. 302, each long and narrow, with finger-like process on inner margin, which is blunt at apex and projects about one-fourth the length of the style. Dorsal portion of aedeagus long and slender, bowed upward at base; ventral paired processes long and slender, with a slender branch arising on inner margin about two-fifths the distance from each apex.

This is a common species in some northeastern states. It has been recorded from New York, Pennsylvania, and Ohio, but has not been taken in Illinois. It is similar to *collaris* in genital characters.

27. *Cloanthanus collaris* (Sanders & DeLong)

Platymetopius collaris Sanders & DeLong (1919, p. 232).

Length 4.5 mm. Closely related to *fulvus*; vertex more bluntly angled and pronotum dark brown or black. Vertex in male more than two-thirds as wide between eyes at base as median length. Median pale vitta at apex of vertex conspicuous. Pronotum dark brown to black, the lateral margins often paler. Scutellum with anterior half black, posterior portion brown. Elytra dark brown, costal veins and veins on apical portions brown, areoles occurring only just anterior and posterior to the apical cross-veins. Face pale brown. The male genitalia are similar to those of *fulvus*. Aedeagus with the long slender paired ventral processes each branched on inner margin about two-fifths the distance from apex.

This species, which is characteristically marked, is known at present only from the mountains of Pennsylvania.

28. *Cloanthanus frontalis* (Van Duzee)

Platymetopius frontalis Van Duzee (1890b, p. 112).

Length 4.0–4.5 mm. Vertex short, bluntly angled, three-fourths as wide between eyes at base as median length. Color black, vertex with conspicuous white vittae on apical portion. Pronotum usually with traces at least of pale longitudinal vittae. Scutellum black. Elytra heavily irrorate with dark brown or black, with numerous small white spots and white areoles; apex of each broadly margined with black. Face bright yellow, infuscated at sides and darker above. Male plates almost as long as pygofer. Each style, fig. 306, abruptly narrowed at about two-thirds its length, apical third slender and produced into finger-like process. Dorsal portion of aedeagus rather long, broadly curved at base; ventral paired processes long and slender, reaching almost to tips of pygofer.

This is a common species throughout Illinois, occurring on leguminous and other herbaceous plants and crops. It is recorded from the eastern United States, the Middle West, and California.

Illinois Records.—Many males and females, taken May 17 to October 3, are from Adair, Anvil Rock, Arlington Heights, Atlas, Barry, Beach, Bushnell, Cairo, Cave in Rock, Cobden, Cornfield, Cypress, Danville, Decatur, Des Plaines, Dolson, DuBois, Eichorn, Elizabeth, Evergreen Park, Fairfield, Fern Cliff, Fulton, Geff, Gibsonia, Glencoe, Grafton, Grand Detour, Grays Lake, Hamburg, Hanover, Hardin, Harrisburg, Havana, Herod, High Knob, Homer, Justice, Kampsville, Karnak, Kinmundy, Kirkwood, Lawrenceville, Luther, Makanda, Marshall, Momence, Mount Carmel, Muncie, New Holland, Normal, Oak Lawn, Oquawka, Oregon, Ozark, Princeton, Pulaski, Quincy, Seymour, Shawneetown, Sparta, Starved Rock State Park, Summit, Ullin, Urbana, Ursa, Vandalia, Vienna, Virginia, Ware, Watson, Waukegan, Wolf Lake, and Zion.

29. *Cloanthanus slossoni* (Van Duzee)

Platymetopius slossoni Van Duzee (1910, p. 222).

Length 4 mm. Resembling *acutus* in color but with a long sharp pointed vertex. Definitely less than half as wide between eyes

at base as median length; pale brownish, with pale longitudinal vittae. Pronotum dark brown, with five pale longitudinal vittae. Elytra pale, with brownish irrorations and brown veins, leaving many pale areas and pale areolar spots. Face yellow, infuscated with brown at margins and above. Male plates almost as long as pygofer, gradually narrowed to blunt tips. Apical one-third of each style, fig. 304, narrowed to form a thick finger-like process. Dorsal portion of aedeagus slightly tapered to a blunt apex; ventral paired processes narrow, scarcely widened at apexes, tips sharp pointed.

This long-headed species is known only from Florida.

50. *ACURHINUS* Osborn

Acurhinus Osborn (1920, p. 153).

Fig. 205. Head strongly produced, the vertex with sides nearly straight, apex acute, slightly concave above; frons reaching close to eyes, antennal pits touching eyes, and ocelli very close to eye borders; a distinct furrow beneath the front margin between vertex and front; front strongly convex. Costa with strongly reflexed veinlets next to the outer anteapical cell, which is much reduced.

Only one species from the United States is placed in this genus.

1. *Acurhinus pyrops* (Crumb)

Deltocephalus pyrops Crumb (1915, p. 191).

Length 3.5-4.0 mm. Brownish yellow, with a very long pointed vertex. Eyes and ocelli bright red. Vertex with a black spot on either side of apex, a posterior spot and two pairs of transverse marks on disc fuscous. Face yellow, margined above with brown. Elytra pale, nervures margined with fuscous, costal areas yellowish.

Female seventh sternite, fig. 290C, with posterior margin gradually sloping to the middle third, which is almost squarely excavated one-fourth the distance to base and bears a short broad black tooth. Male plates, fig. 290, short and broad, lateral margins convexly rounded to broad blunt slightly divergent apexes.

This species occurs in the eastern United States, and is abundant in Illinois.

Illinois Records.—Many males and fe-

males, taken June 12 to October 3, are from Albion, Alton, Anvil Rock, Cave in Rock, Dixon Springs, Dolson, Dongola, Eichorn, Elizabethtown, Geff, Herod, Metropolis, Parker, St. Anne, Vienna, and Watson.

51. *FLEXAMIA* DeLong

Flexamia DeLong (1926a, p. 22).

Figs. 224, 326. Vertex strongly produced, pointed, disc flattened or slightly depressed, acutely and sharply angled with the front.

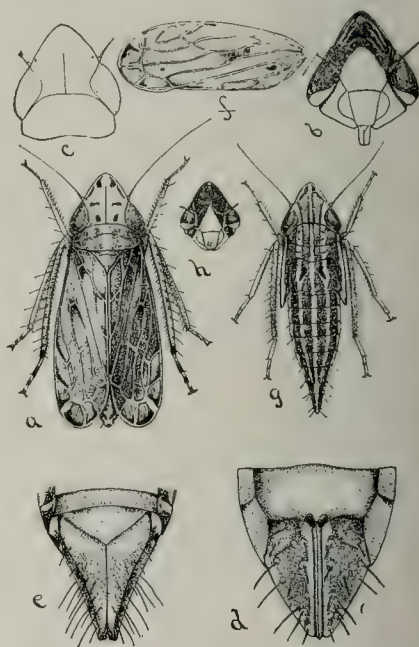


Fig. 326.—*Flexamia reflexa*: a, adult; b, face; c, head and pronotum; d, female genitalia; e, male genitalia; f, elytron; g, nymph; h, face of nymph. (From Osborn.)

Face elongated, elytra with apical costal veinlets reflexed or very short and right angled. Inner claval veins often partially coalescing, with or without appendix.

The species of this genus are usually conspicuously marked by the broad white coloration on the apical costal reflexed veinlets. In habit they are all grass feeding and live in meadows, pastures, and prairies. Twenty-seven species have been recorded for the United States, chiefly middle western regions. Eleven of these species have been taken in Illinois. Several others may occur in this state.

KEY TO SPECIES

1. Vertex, pronotum, and scutellum, fig. 327*A*, marked by heavy coalescing black bars and spots giving the appearance of a black wedge-shaped marking extending onto clavus of each elytron. 1. **rubranura**
Vertex, pronotum, and scutellum without heavy black markings in the form of coalescing bars and spots. 2
2. Color bright yellow or yellowish olive, with a large round black spot on center of each elytron; vertex, fig. 327*B*, without transverse marking. 2. **areolata**
Color white, yellowish gray, or brownish yellow, spots when present on elytra smaller; vertex with transverse markings or longitudinal stripes, or both. 3
3. White or lemon yellow, marked with conspicuous brown longitudinal stripes on base of vertex, on pronotum, and on scutellum. 4
Some shade of brownish or grayish yellow, not white, and without definite longitudinal stripes on base of vertex, on pronotum, and on scutellum. 5
4. Length not over 4.5 mm. Head and pronotum, fig. 327*C*, white with brown stripes. Elytra not appearing longitudinally striped. 3. **albida**
Length more than 5 mm. Head and pronotum, fig. 327*D*, lemon yellow, with brown stripes. Elytra appearing longitudinally striped. 4. **grammica**
5. Vertex broad, as wide between eyes as median length or slightly longer than width at base. 6
Vertex more narrowed, decidedly longer at middle than basal width between eyes. 7
6. Female seventh sternite, fig. 328*E*, with central obtuse lobe incised at middle and bearing a conspicuous black tooth at middle on each side. Male plates, fig. 337, truncate and divergent at tips; inner margins of pygofers enclosing long black styles that exceed plates. 5. **stylata**
Female seventh sternite, fig. 328*F*, without conspicuous black teeth on margins of central lobe. Male plates, fig. 338, convexly rounded to bluntly pointed apices; styles not visible. 6. **inflata**
7. Female. 15
Male. 8
8. Male plates, fig. 339, scarcely narrowed apically, broadly rounded. 7. **pectinata**
Male plates decidedly narrowed apically, apices not broadly rounded, as in fig. 342. 9
9. Male plates, fig. 342, strongly divergent on apical third, apices pointed. 8. **sandersi**
Male plates with apices appressed or proximal, not divergent on apical third, as in fig. 340. 10
10. Male plates rather long, concavely rounded or straight on outer margins, not greatly exceeded by pygofers, as in fig. 340. 11

Male plates shorter, convexly rounded to blunt apices, exceeded by pygofers by at least half their length, as in fig. 332. 13

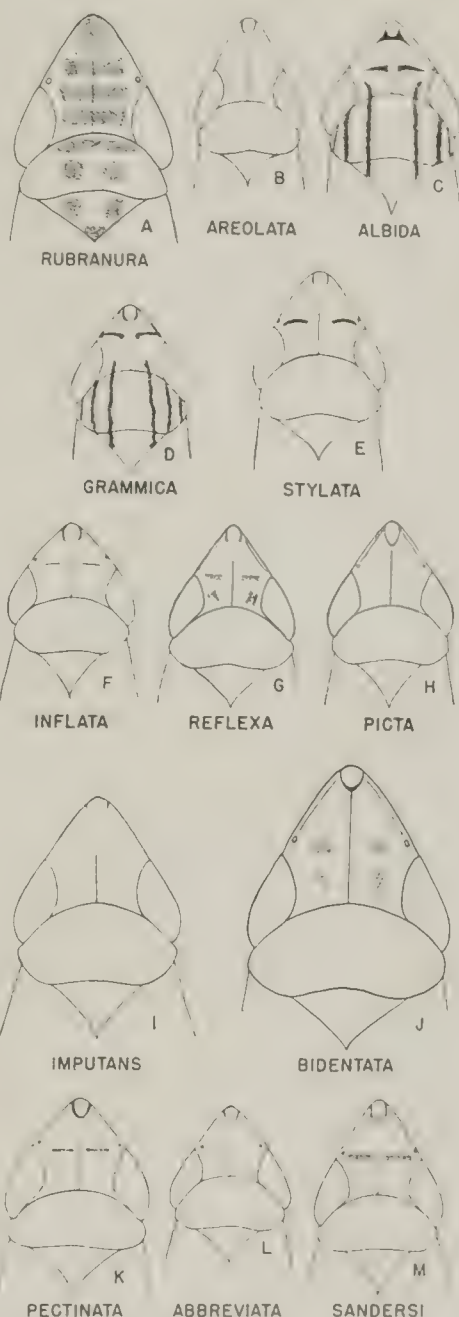


Fig. 327.—*Flexamia*, A–M, heads and pronota.

11. Male plates, fig. 340, with produced finger-like processes on outer margins at apexes. Aedeagus with two terminal serrate processes.....**9. bidentata**
Male plates without finger-like processes on outer margins at apexes. Aedeagus with three terminal processes, as in fig. 341.....**12**
12. Aedeagus, fig. 341, with a dorsal terminal process; a large ventral process with two large spines at base; small processes at apex of aedeagus not serrate.....**10. reflexa**
Aedeagus, fig. 329, without a dorsal terminal process; large ventral process without spines; small lateral apical processes serrate.....**11. prairiana**
13. Plates very short, pygofer exceeding plates by their length. Aedeagus, fig. 331, with two terminal lateral processes.....**12. picta**
Plates long, pygofer exceeding plates by about one-half their length, as in fig. 332.....**14**
14. Aedeagus, fig. 332, with terminal processes. Color creamy yellow, face black.....**13. imputans**
Aedeagus, fig. 330, without terminal processes. Color pale cinereous, face infuscated.....**14. abbreviata**
15. Female seventh sternite, fig. 328G, notched, forming four median teeth on posterior margin.....**7. pectinata**
Female seventh sternite with not more than two distinct teeth, as in fig. 328K.....**16**
16. Median notch on female seventh sternite, fig. 328K, forming two broad teeth, each of which is either truncate or concave at apex.....**14. abbreviata**
Teeth of median portion of seventh sternite, if present, sharp pointed, sometimes wanting.....**17**
17. Posterior margin of seventh sternite truncate or sloping from lateral angles to median produced portion, figs. 328I, 328J.....**10. reflexa**, **8. sandersi**

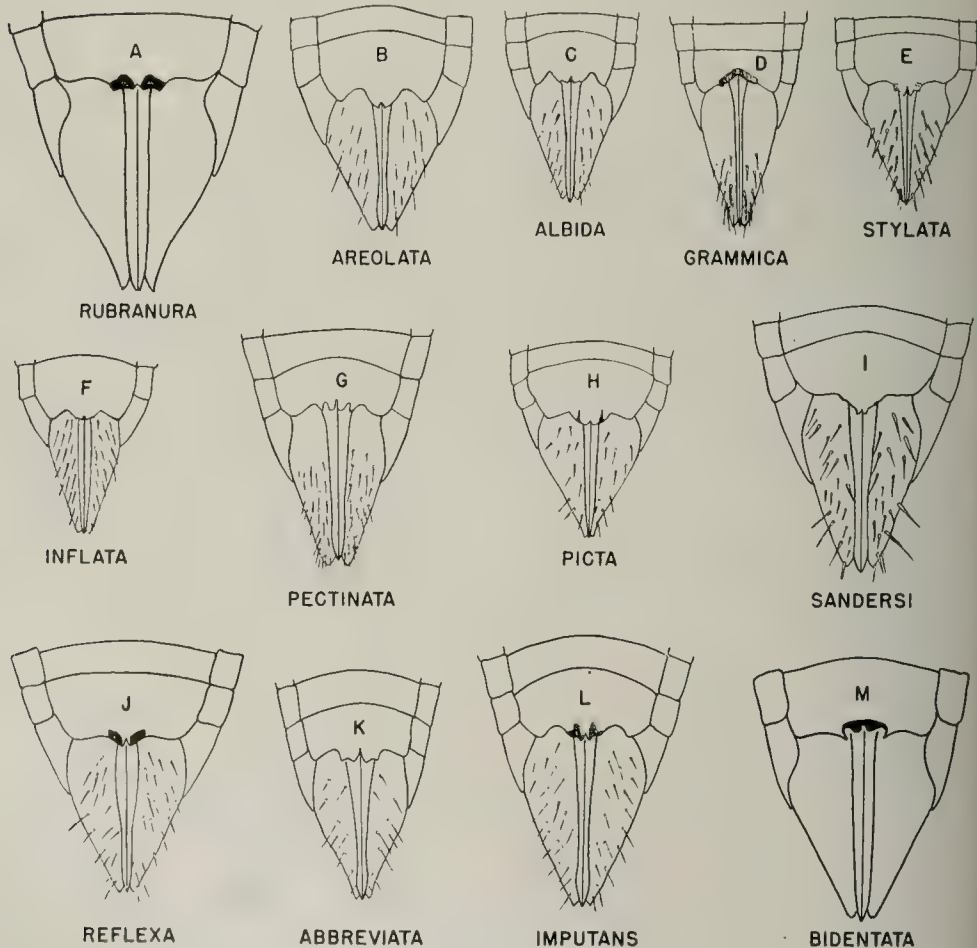
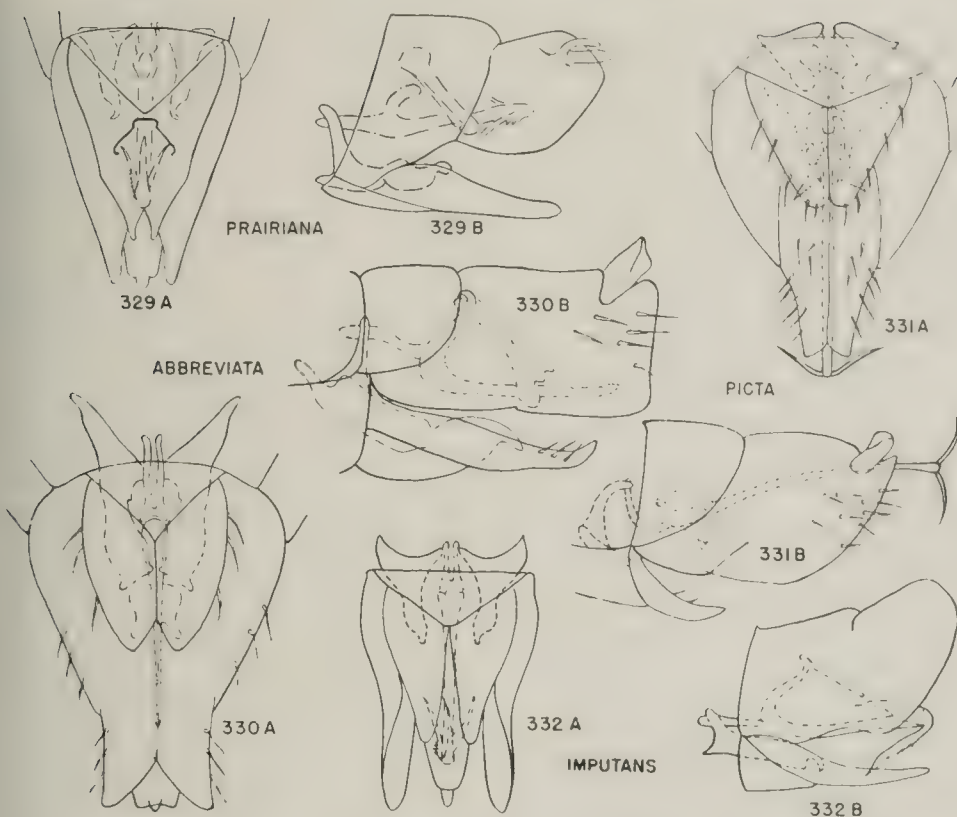


Fig. 328.—*Flexamia*, A–M, female genitalia.



Figs. 329-332.—*Flexamia*, male genitalia. *A*, ventral aspect; *B*, lateral aspect.

Posterior margin of seventh sternite broadly notched or concavely emarginate between lateral angles and median notch, as in fig. 328*L*. 18

18. Creamy yellow in color, face black. 13. *imputans*

Pale cinereus in color, face infuscated and with some pale markings. 19

19. Usually heavily marked with black or dark fuscous, nervures of veins heavily infuscated. 12. *picta*

Usually not heavily marked with black, nervures of elytra only moderately infuscated. 11. *praaryana*, 9. *bidentata*

1. *Flexamia rubranura* DeLong

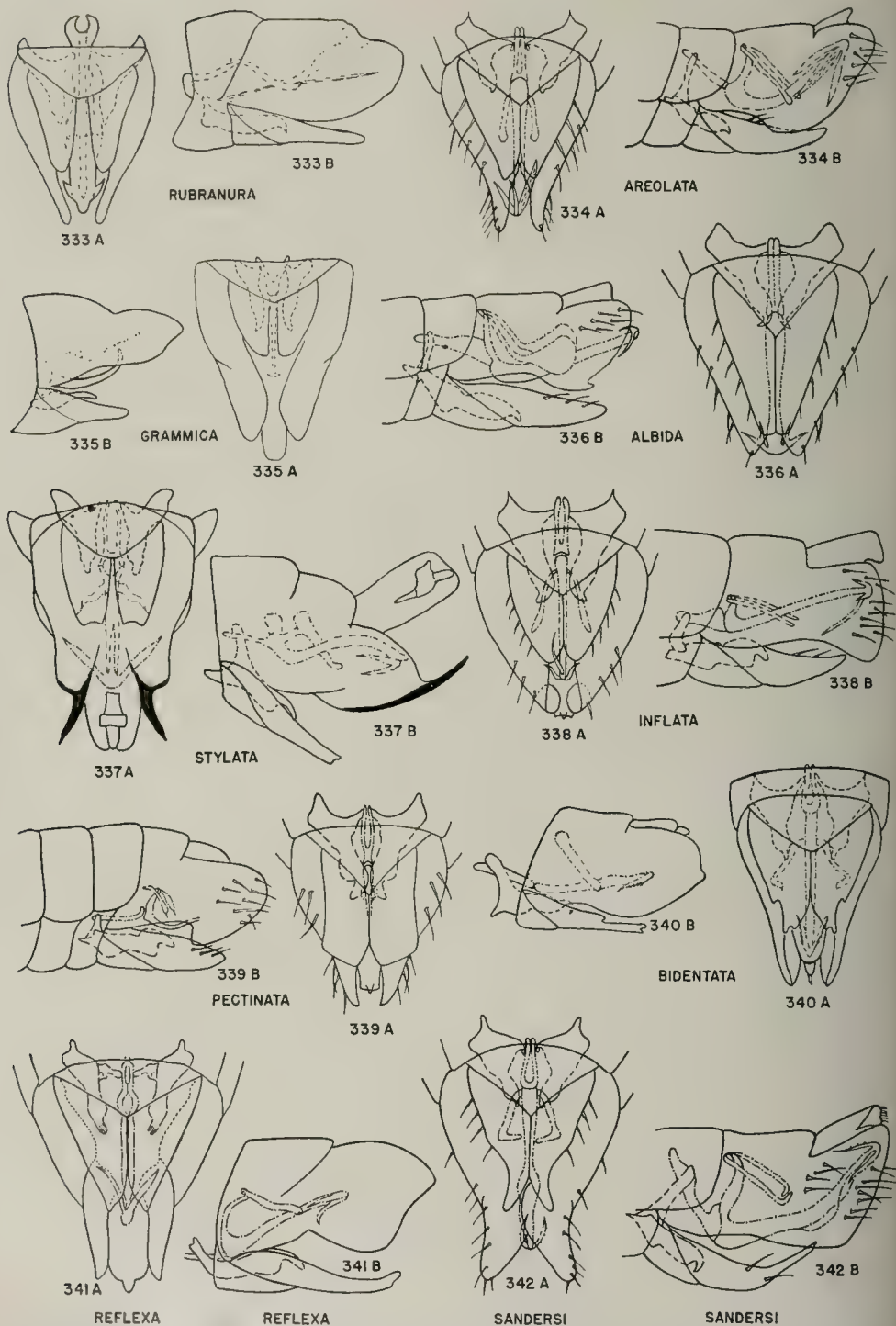
Flexamia rubranura DeLong (1935*a*, p. 154).

Length 3.0-3.2 mm. Yellowish, with heavy markings. Vertex, fig. 327*A*, one-third longer than width between eyes. Elytra short, covering only the first three or four abdominal segments. A broad black wedge-shaped mark composed largely of wide black transverse bars extending from apex of vertex to claval area of the elytra; a pair of black spots on pronotum behind

the eyes and two pairs at about the middle of the wings. Abdomen with four longitudinal black lines. Face and venter dark brown to black. Tips of male pygofer bright red.

Female seventh sternite, fig. 328*A*, almost truncate, middle third slightly produced and notched, forming a broad truncated or concavely rounded tooth on either side and with a black spot on either side of middle. Male plates gradually tapered to broadly rounded apices that are about one-half as wide as basal width, exceeded in length by the bright red pygofer. Aedeagus, fig. 333, with body short; a process arises on either side and extends into genital chamber; a ventral process arises from base, curves ventrally and caudally and lies between the terminals of the two dorsal branches; ventral process consists of two long slender parallel and proximal processes.

This species was described from northern Illinois, where it occurs on the moist prairies in at least two localities.



Figs. 333-342.—*Flexamia*, male genitalia; both internal and external structures shown. A, ventral aspect; B, lateral aspect.

Illinois Records.—EVERGREEN PARK: Aug. 23, 1934, DeLong & Ross, 24 ♂, 42 ♀; July 1, 1935, DeLong & Ross, 5 ♂. SUMMIT: July 17, 1935, DeLong & Ross, 12 ♂, 12 ♀.

2. *Flexamia areolata* (Ball)

Deltocephalus areolatus Ball (1899b, p. 188).

Length 3.5–4.0 mm. Pale olive to bright yellow. Vertex, fig. 327B, more than one-half longer at middle than width between the eyes, with crescent marks at apex enclosing a white spot. Elytra each with a large black or fuscous blotch between sectors and behind the first cross nervure, the outer apical margin and anterior borders of the broad white reflexed veins fuscous. Face and venter black.

Female seventh sternite, fig. 328B, with the posterior margin angularly excavated one-fourth the distance to base on either side of a rounded medially notched tooth, which is one-fourth the width of segment and equals the lateral angles in length. Male plates gradually narrowed to bluntly pointed divergent apices. Aedeagus, fig. 334, with three terminal processes, the two shorter processes smooth; longer process heavily clothed with coarse pubescence.

This species is a prairie type occurring on a *Panicum* or a closely related genus, which grows on sand prairies and in similar habitats. It is very common throughout the prairies of Illinois and is recorded from the eastern United States and west to Arizona.

Illinois Records.—Males and females, taken June 14 to October 4, are from Apple River Canyon State Park, Barry, Carman, Cave in Rock, Dixon Springs, Eichorn, Fulton, Hanover, Havana, Marshall, Quawka, Oregon, Port Byron, St. Anne, Thomson, Urbana, Vienna, and Watson.

3. *Flexamia albida* (Osborn & Ball)

Deltocephalus albidus Osborn & Ball (1897, p. 201).

Length 4.25 mm. Milky white, with brown marking. Vertex, fig. 327C, a little longer at middle than basal width between eyes, a black or dark brown triangular margin enclosing pale spot at apex, a transverse band between eyes, and four or six longitudinal lines across pronotum, the inner pair arising on the base of vertex and extending across scutellum on to elytra. Elytra

with claval and apical margins, anterior borders of reflected veins, and spots on each clavus and disc, brown or black.

Female seventh sternite, fig. 328C, divided into three lobes by two angular excavations extending one-third the distance to base; central lobe almost as broad as the combined width of the other two, incised at middle, and with a slight blunt tooth on either side. Male plates gradually tapering to blunt convexly rounded apices. Aedeagus, fig. 336, with a pair of terminal processes, each branched near base and giving rise to two short ventrally or laterally directed spines.

A distinctly marked species, *albida* occurs only in prairie habitats in a few middle western states.

4. *Flexamia grammica* (Ball)

Deltocephalus grammicus Ball (1900b, p. 204).

Length 5.25 mm. Lemon yellow, marked with brown stripes. Vertex, fig. 327D, about one-fifth longer at middle than width between eyes; white, washed with yellow; fuscous crescent marks at apex, marginal line and a transverse medially interrupted band between ocelli also fuscous; a pair of dark brown longitudinal stripes arising on basal third of vertex and continuing across pronotum and scutellum. Pronotum with two additional lines behind each eye; four central lines continuing on to elytra, the two on each side converging and uniting before tip of clavus, where they terminate. Three other bands paler in color on each elytron interrupted by pale yellow veins. Face yellow, a black line just beneath margin of vertex.

Female seventh sternite, fig. 328D, with posterior margin angularly excavated one-third the distance to the base; margin of excavation near center slightly toothed and marked with black. Male plates short and broad, with broadly rounded apices. Aedeagus, fig. 335, slender with two very short laterally directed terminal processes; a short dorsal process arises at base and has a pair of longer processes at its apex.

An abundant species on the sand prairies in Illinois, *grammica* is one of the most striking in color of this genus. It has been recorded previously from Colorado and Nebraska.

Illinois Records.—FULTON: Aug. 22, 1935, DeLong & Ross, 5 ♂. THOMSON:

June 30, 1935, DeLong & Ross, 113 ♂, 101 ♀; Aug. 16, 1937, Ross & Burks, 1 ♂, 4 ♀.

5. *Flexamia stylata* (Ball)

Deltocephalus stylatus Ball (1899b, p. 190).

Length 4.5 mm. Pale cinereous. Vertex, fig. 327E, very slightly longer than its basal width, yellowish, with apical dark spots and with a transverse broken line between ocelli. Elytra marked as in *flexulosa* (Ball) (1899b, p. 199), nervures pale, margined with fuscous; outer region of each clavus with a dark spot on either side of first cross nervure of the disc.

Female seventh sternite, fig. 328E, with posterior margin produced on the middle third into an obtusely triangular tooth, bifid at apex and bearing a small lateral tooth on either side. Male plates, fig. 337, roundly divergent at the apices, which are half as wide as at the bases; apices truncate or slightly and roundly emarginate. Styles long, narrow, black, exceeding pygofer.

This prairie species has been collected only rarely, and very little is known of its food habits. It has been recorded from Iowa and Nebraska.

6. *Flexamia inflata* (Osborn & Ball)

Deltocephalus inflatus Osborn & Ball (1897, p. 202).

Length 3.0–4.5 mm. Yellowish to brownish. Vertex, fig. 327F, almost as wide between eyes as length at middle, similarly marked as in *stylata*. Pronotum and scutellum with longitudinal markings. Elytra with veins on each clavus, on the disc, and on apical portion of each elytron bordered with fuscous.

Female seventh sternite, fig. 328F, with posterior margin roundly notched on either side of a central broad produced lobe, which is notched at center and bears a black spot and slight tooth on the sloping sides. Male plates, fig. 338, gradually and convexly rounded to appressed roundly pointed apices, sometimes notched at apices by the sharp pygofer edges. Pygofers enlarged and inflated. Aedeagus with a pair of short lateral terminal processes and a long slender ventral process that is twice the length of the lateral.

This is one of the most common grass-feeding species in Illinois and occurs abun-

dantly in meadow, pasture, and prairie habitats.

It is distributed over the eastern United States and west to Colorado.

Illinois Records.—Many males and females, taken May 30 to September 20, are from Alsip, Amboy, Antioch, Barry, Beach, Des Plaines, Evergreen Park, Fulton, Homer, Kankakee, Macomb, McHenry, Oak Lawn, Odin, Ogden, Oquawka, Orangeville, Palos Park, Pike, Princeton, St. Anne, Shawneetown, Summit, Urbana, Vienna, Wauconda, and White Pines Forest State Park.

7. *Flexamia pectinata* (Osborn & Ball)

Deltocephalus pectinatus Osborn & Ball (1897, p. 205).

Length 3.5–4.0 mm. Dorsum pale cinereous. Vertex, fig. 327K, one-fourth longer than basal width between eyes, with the usual marks at apex and on disc for the more typical members of the genus. Elytra with nervures pale, margined with fuscous; apical and discal cells darker. Face dark above, shading to pale below.

Female seventh sternite, fig. 328G, with posterior margin slightly concave and bearing four black comblike teeth on the central third; inner pair rounded and close together and separated by a notch from the outer pointed pair. Male plates, fig. 339, broad, almost parallel margined and broadly rounded to blunt almost truncate tips. Ventral keels of pygofers exposed between the plates at their apices. Aedeagus simple, without terminal processes; very short curved basal portion extending anteriorly, with a pair of short dorsal processes.

This distinctive species occurs in a mixed association on the prairie and seems to live on *Bouteloua* grasses. It has been recorded from only the Middle West.

Illinois Records.—APPLE RIVER CANYON STATE PARK: July 11, 1934, Frison & DeLong, 3 ♂; Aug. 22, 1935, DeLong & Ross, 5 ♀. OGDEN: on prairie, July 1, 1934, DeLong & Ross, 1 ♀. WARREN: Aug. 28, 1934, Frison & DeLong, 1 ♀.

8. *Flexamia sandersi* (Osborn)

Deltocephalus sandersi Osborn (1907, p. 164).

Length 3.5 mm. Yellowish gray; vertex, fig. 327M, about one-third longer at middle than width between eyes at base, with the

pale tip enclosed in a darker circular or quadrate ring; margins with pale fuscous lines from apex to ocelli and with the usual transverse band and basal oblique marks. Nervures of elytra usually paler than surface; apical margin of each elytron and costal reflexed veins heavily bordered with dark fuscous.

Female seventh sternite, fig. 328I, with lateral margins rounding to median third of posterior margin, which is strongly produced into a broad tooth slightly incised at middle and black on either side. Male plates, fig. 342, broad at base, narrowed rapidly for two-thirds their length, then abruptly concave and strongly divergent, with acutely pointed apices. Aedeagus with two terminal anteriorly directed processes that are short and barbed.

This is another typical prairie species, which occurs on *Andropogon virginicus* and probably other species of the same genus. It is found in the eastern United States and west to Illinois.

Illinois Records.—ANVIL ROCK: Oct. 3, 1934, Frison & Ross, 1 ♀. CAVE IN ROCK: Oct. 3, 1934, Frison & Ross, 1 ♂, 1 ♀. DIXON SPRINGS: July 29, 1934, DeLong & Mohr, 1 ♀. EICHORN: Hicks Branch, June 13, 1934, DeLong & Ross, 2 ♂, 3 ♀. HIGH KNOB: Oct. 3, 1934, Frison & Ross, 1 ♀. LA RUE: July 11, 1934, DeLong & Ross, 1 ♀. SHAWNEETOWN: June 23, 1936, DeLong & Ross, 2 ♀. VIENNA: savanna grasses, June 14, 1934, DeLong & Ross, 3 ♂, 4 ♀; July 29, 1934, DeLong & Ross, 3 ♂, 4 ♀.

9. *Flexamia bidentata* DeLong

Flexamia bidentata DeLong (1935a, p. 155).

Length 3.0–3.3 mm. Tawny, marked with brown. Vertex, fig. 327J, with the usual markings at apex and on disc. Veins of elytra heavily infuscated. Female seventh sternite, fig. 328M, with a large median tooth, which is bifid at apex, forming two sharp-pointed teeth. Male plates, fig. 340, similar to those of *visenda* (Crumb) (1915, p. 189) but broader at apices and more deeply notched on inner margins. Male pygofers without the broad conspicuous ventral flaps that overlap as in *visenda*. Male aedeagus with two terminal processes.

This species was described from Illinois and has been taken in two localities, both on the prairies.

Illinois Records.—ST. ANNE: Aug. 21, 1935, DeLong & Ross, 5 ♂, 10 ♀. ZION: June 25, 1934, Frison & DeLong, 2 ♂, 2 ♀; Aug. 7, 1935, Ross & DeLong, 5 ♂.

10. *Flexamia reflexa* (Osborn & Ball)

Deltocephalus reflexus Osborn & Ball (1897, p. 203).

Length 4.0–4.5 mm. Pale cinereous, with dark markings. Vertex, fig. 327G, about one-fourth longer at middle than basal width between eyes; apex often ivory white, enclosed between crescent marks; marginal line to ocelli, transverse dashes before eyes, and oblique marks on base fuscous. Pronotum pale, with faint longitudinal stripes. Nervures of elytra margined with fuscous; spots on each clavus and on disc conspicuous; reflexed veins, apical margin of each elytron broadly bordered with fuscous.

Female seventh sternite, fig. 328J, with posterior margin almost truncate, central third roundedly and broadly produced into a tooth that is notched at center and has a large black spot on either side of notch. Male plates, fig. 341, long, rather narrow, and concavely and attenuately pointed. Aedeagus with three anteriorly directed terminal processes, one of which occurs on the dorsal side; the largest process with two spines on basal portion.

A common prairie species of the Middle West, *reflexa* has apparently been confused with other closely related species of *Flexamia*, thereby rendering many reports of its occurrence and abundance as unreliable.

Illinois Record.—OQUAWKA: sand prairie, July 30, 1936, Mohr & Burks, 1 ♀.

11. *Flexamia prairiana* DeLong

Flexamia prairiana DeLong (1937a, p. 32).

Length 4.0–4.5 mm. Yellowish, closely resembling *reflexa*. Vertex about one-fifth longer at middle than basal width between eyes, with apical dark ring and cross band on disc. Elytra yellowish, veins bordered with brown, especially heavy along reflexed veins to each costa.

Female seventh sternite rather deeply emarginate on either side of the median produced third, which is rounded at apex and notched so as to form several minute teeth. Male plates, fig. 329, long, tapered to pointed apices, which are slightly divergent. Aedeagus bearing three anteriorly directed

processes as in *reflexa*, but differing by the absence of a process on the dorsal side and by having the large process on ventral side. In this species there is a finely serrate smaller lateral process.

This is a common species on sandy lake-bottom prairies and probably the most abundant species of this genus in the northern part of Illinois. It is known only from this state.

Illinois Records.—ALSIP: Aug. 23, 1934, DeLong & Ross, 11 ♂. EVERGREEN PARK: Aug. 23, 1934, DeLong & Ross, 41 ♂. SUMMIT: July 17, 1935, DeLong & Ross, 2 ♀. ZION: July 16, 1935, DeLong & Ross, 1 ♂.

12. *Flexamia picta* Osborn

Deltocephalus pictus Osborn (1907, p. 165).

Length 3 mm. Pale gray, vertex, fig. 327H, about one-fifth longer than width between eyes, a black circle at tip enclosing a pale spot; the usual marginal line, one or two transverse bands, and spots at base are present. Pronotum with prominent transverse band. Elytra with veins pale, usually heavily bordered with fuscous or black; central apical cell often entirely brown or black.

Female seventh sternite, fig. 328H, almost truncate, central third broadly and roundedly produced, two small incisions form a minute tooth at apex on either side of a median rounded lobe. Male plates, fig. 331, slightly and convexly rounded to blunt apices. Pygofers more than twice as long as plates. Aedeagus with two slender laterally directed apical processes.

This species occurs in the eastern United States, especially on hillsides and in certain prairie types where *Aristida gracilis* and related species grow in abundance.

Illinois Records.—Males and females, taken June 12 to October 3, are from Adair, Albion, Alton, Amboy, Anvil Rock, Barry, Cave in Rock, Dixon Springs, Dongola, Fairfield, Galena, Geff, Harrisburg, Kampsville, Marshall, Metropolis, Parker, Pike, Shawneetown, Vienna, and Watson.

13. *Flexamia imputans* (Osborn & Ball)

Deltocephalus imputans Osborn & Ball (1898, p. 75).

Length 3.5–4.0 mm. Creamy yellow, tinged with olive. Vertex, fig. 327I, about one-third longer at middle than width be-

tween eyes, a black spot on either side of pale apex. Reflexed veins of elytra broadly white, margined anteriorly with fuscous; outer apical cell of each elytron with the posterior margin fuscous. Face black, venter infuscated.

Female seventh sternite, fig. 328L, with emargination posteriorly on either side of a central broadly produced lobe that is angular and somewhat incised at center and has a black spot on either side. Male plates, fig. 332, gradually narrowed to rounded divergent tips.

This species has been recorded from Kansas, Iowa, and Wisconsin, and is found on *Muhlenbergia* growing in sheltered situations.

14. *Flexamia abbreviata* (Osborn & Ball)

Deltocephalus abbreviatus Osborn & Ball (1897, p. 206).

Length 3.0–3.25 mm. Pale, cinereous, with vertex markings nearly as in *reflexa*. Vertex, fig. 327L, at least one-third longer at middle than basal width between the eyes. Elytra with almost all the veins dark margined, reflexed veins and apical margin of each more heavily marked. Entire face infuscated.

Female seventh sternite, fig. 328K, with posterior margin excavated on either side of the central fourth, which is abruptly produced one-third the length of the segment, truncated, incised at middle, and slightly arcuate on either side, forming four rather distinct teeth. Male plates, fig. 330, convexly rounded from bases and slightly rounded from inner margins near tips to bluntly pointed apices. Pygofers narrow, greatly exceeding plates. Aedeagus curved, rather long, without apical processes; anterior dorsally curved portion bearing a bifurcate dorsal process with rather long ventrally directed arms.

Another of the prairie species, *abbreviata* occurs along with *pectinata* in the *Bouteloua hirsuta* association. It is recorded only from the Middle West and Texas.

Illinois Record.—THOMSON: July 8, 1934, DeLong & Ross, 21 ♂, 39 ♀.

52. *LATULUS* DeLong & Slesman

Latulus DeLong & Slesman (1929, p. 87).

Fig. 222. Vertex angularly produced, but usually not greatly longer than width be-

tween eyes. Reflexed arcs of front not visible from above. Elytra with short veinlets meeting each costa at about right angles but with no reflexed veins to costa; elytra usually short, just covering abdomen.

The species of this genus are typically wet meadow forms and with few exceptions occur in that habitat. Several are found at high mountain elevations. Eleven species are known for the United States, of which two have been collected in Illinois; two others may occur here.

KEY TO SPECIES

1. Color gray to dull green; length 4.0 mm. or more. Female seventh sternite, fig. 343, with a pair of median produced teeth. Male plates, fig. 344, shorter than combined basal width, apices obliquely sloping. **1. configuratus**
Color some shade of brown; length not exceeding 3.5 mm. Female seventh sternite without median teeth. Male plates longer than combined basal width. **2**
2. Female seventh sternite, fig. 343, deeply notched at either side, forming a broad median tooth. Male plates, fig. 344, divergent at apices, sloping to outer margins. **2. latidens**
Female seventh sternite entire, not deeply notched. Male plates not divergent at apices. **3**
3. Female seventh sternite, fig. 343, concave. Male plates, fig. 344, sloping to inner pointed appressed apices. **3. sayi**
Female seventh sternite, fig. 343, rounded. Male plates, fig. 344, broader at rounded apices, not pointed on inner margins. **4. missellus**

1. *Latulus configuratus* (Uhler)

Deltoccephalus configuratus Uhler (1879, p. 511).

Length 4.0–4.5 mm. Gray to dull greenish. Vertex, fig. 343, flat, bluntly angled, wider between eyes than length at middle, marked with a white cross and with the margin pale. Pronotum usually marked by longitudinal bands. Nervures of elytra paler than adjacent areas, faintly margined with fuscous. Face pale fuscous.

Female seventh sternite, fig. 343, black on central half with the posterior margin concavely rounded on either side of a rather long pointed median tooth, which is usually bifid. Male plates, fig. 344, gradually sloping along outer margins; inner margins suddenly diverging at two-thirds their length and rounded to outer blunt apices. Aedeagus short, apical fifth bifid.

This species has a northern range throughout Canada and the northern portion of the United States. It is common on *Poa compressa* and may occur in northern Illinois.

2. *Latulus latidens* (Sanders & DeLong)

Deltoccephalus latidens Sanders & DeLong (1919, p. 234).

Length 3 mm. The size, form, and appearance as for *missellus*, but distinguished

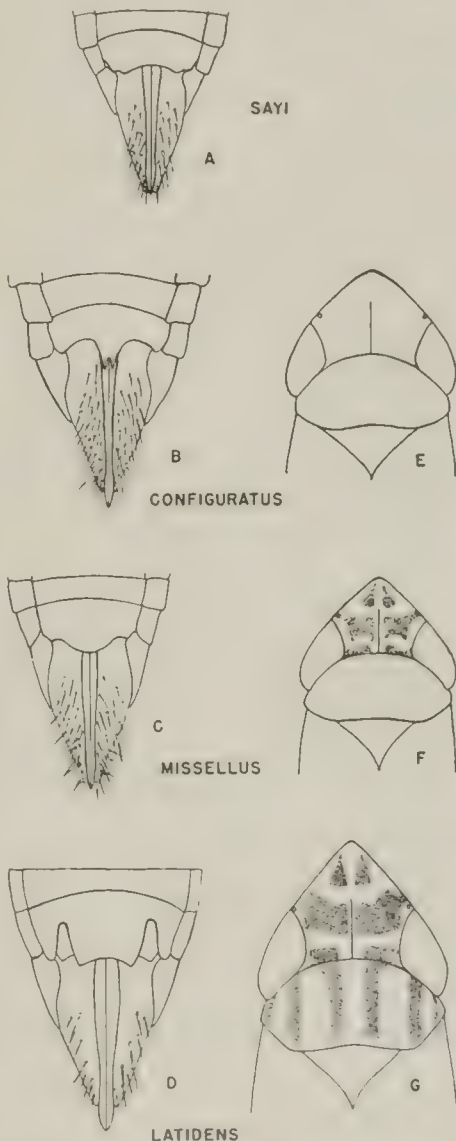


Fig. 343.—*Latulus*. A-D, female genitalia; E-G, heads and pronota.

by the external genital characters. Female seventh sternite, fig. 343, more than twice as long as preceding sternite, posterior margin deeply and roundedly incised near lateral margins for two-thirds the distance to base, leaving a broad central truncated tooth; tooth one-half the width of entire segment and produced beyond the lateral angles, the latter appearing as long, narrow, spatulate processes. Male plates, fig. 344, long, strongly divergent, inner margins curving to form bluntly pointed outer margins.

This species has been recorded only from Wisconsin and occurs in wet meadows and pastures.

3. *Latulus sayi* (Fitch)

Amblycephalus sayi Fitch (1851, p. 61).

Length 3.5 mm. Yellowish to brownish, with banded elytra. Vertex longer at middle than width between eyes, with four fuscous spots arranged in two somewhat concentric rows about the apex; anterior spots triangular, the posterior pair somewhat irregular in shape. Elytra each with two transverse pale bands, one at base and another just posterior to the middle; nervures of bands usually milky white.

Female seventh sternite, fig. 343, with posterior margin shallowly, concavely, and

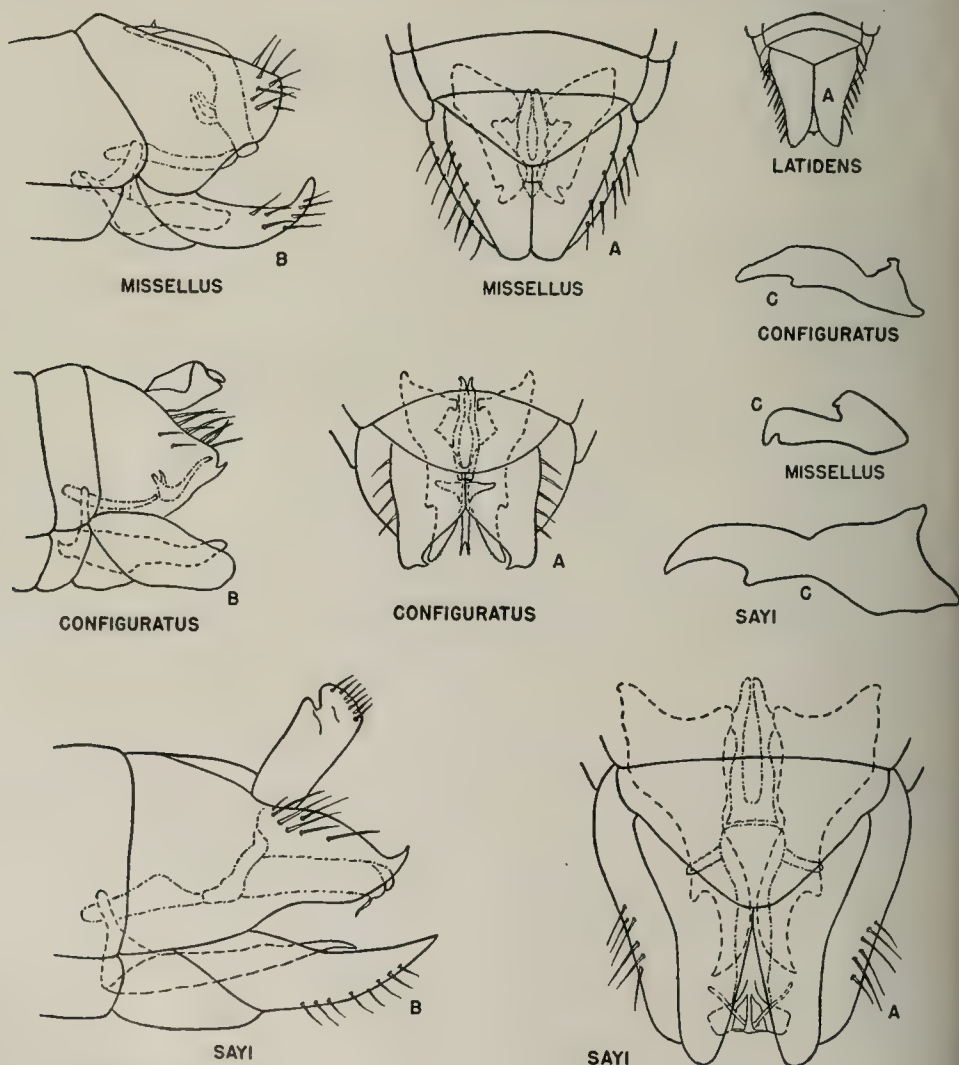


Fig. 344.—*Latulus*, male genitalia. A, ventral aspect; B, lateral aspect; C, style.

often sinuately rounded. Male plates, fig. 344, with outer margins slightly and concavely narrowed to near apices, where they are suddenly convexly rounded to the inner blunt apices. Aedeagus with two short lateral processes arising dorsally at base; apical portion broadened into winglike structures between which a pair of long slender processes arise and extend ventrally and anteriorly.

This is a common meadow and pasture species occurring upon bluegrass and probably other common grasses in these areas. It has a wide range over the eastern and middle western states.

Illinois Records.—Many males and females, taken from May 3 to November 13, are from Aldridge, Algonquin, Apple River Canyon State Park, Aurora, Browns, Cave in Rock, Decatur, Des Plaines, Dixon, Dolson, Dubois, East St. Louis, Eichorn, Elgin, Elizabethtown, Evergreen Park, Fern Cliff, Galena, Geff, Grand Detour, Hardin, Havana, Herod, Homer, Kankakee, Lima, Mahomet, Makanda, Marshall, Monticello, Muncie, Newton, Oakwood, Odin, Oregon, Palos Park, Princeton, Rago, Rock Island, St. Joseph, Seymour, Shawneetown, Thebes, Urbana, Vandalia, Vienna, Volo, Warren, Watson, White Heath, and White Pines Forest State Park.

4. *Latulus missellus* (Ball)

Deltocephalus missellus Ball (1899b, p. 191).

Length 2.75–3.0 mm. Brownish, resembling *sayi* in general appearance but without distinct banding of the elytra. Vertex, fig. 343F, about as long as wide, pale, with the four brownish spots, as in *sayi*, separated by a white cross, and often with two other irregular spots near base. Elytra pale cinereous; nervures pale, irregularly margined with fuscous.

Female seventh sternite, fig. 343C, with the middle half of posterior margin convexly rounded, on either side of which it is shallowly concave to the lateral angles. Male plates, fig. 344, broad at bases, gradually narrowed to bluntly rounded and slightly divergent apices. Aedeagus with a pair of spinelike structures near the base; apex of dorsal portion pointed.

Distributed from Maine to Utah in the northern region of the United States, *missellus* occurs on grasses in meadows, open woodland, and pastures.

Illinois Records.—Many males and females, taken June 10 to October 7, are from Amboy, Antioch, Apple River Canyon State Park, Beach, Byron, Des Plaines, Duncans Mills, Elizabeth, Evergreen Park, Fox Lake, Galena, Grand Detour, Grays Lake, Hanover, Herod, Lima, New Milford, Oregon, Palos Park, St. Anne, Savanna, Volo, White Pines Forest State Park, and Zion.

53. *PALUS* DeLong & Slesman

Palus DeLong & Slesman (1929, p. 85).

Fig. 221. Vertex variable in length and angle, margin not sharply defined. Elytra each with a definite but small appendix, with central anteapical cell constricted at center but not divided, outer anteapical cell quite small, sometimes almost obsolete; two or three costal veinlets slightly reflexed. Illinois species with dark spot inside posterior angle of inner apical cell.

The coloration and the form of the head vary decidedly among the species of this genus, but the genitalia are quite uniform. Leafhoppers of this genus live in marsh habitats or in very humid swampy woods. Seven species are recorded for the United States, and one of these has been taken in Illinois. Several others may occur in this state.

KEY TO SPECIES

1. Vertex ivory white, tinted with yellow, without dark markings, fig. 346B. 1. *luteocephalus*
Vertex, pronotum, and scutellum with dark longitudinal stripes. 2
2. Vertex sharply angled, longer at middle than width between eyes, fig. 345B; length not exceeding 3.5 mm. 2. *delector*
Vertex more bluntly angled, width and length nearly equal, fig. 347B; length 4.0 mm. or more. 3. *marginatus*

1. *Palus luteocephalus* (Sanders & DeLong)

Deltocephalus luteocephalus Sanders & DeLong (1917, p. 84).

Length 3.5–4.0 mm. Vertex, fig. 346B, a little wider than median length, white to pale yellow, with a median black line on basal two-thirds. Anterior margin of pronotum ivory white, darker posteriorly. Scutellum yellow. Face pale yellow, immaculate, antennal pits black. Elytra smoky subhyaline; claval, discal, and apical cells

darker; costal reflexed veins and apical margin of each heavily bordered with fuscous; nervures conspicuously pale, narrowly margined with fuscous.

Female seventh sternite, fig. 346A, with posterior margin slightly and concavely excavated to a broad median U-shaped notch that has a slight incision at the center; a black spot on either side of notch. Male plates gradually narrowed to bluntly rounded apexes.

A marsh-inhabiting species occurring only in small numbers in this habitat, *luteocephalus* is recorded from Wisconsin and South Dakota. It has not yet been taken in Illinois.

2. *Palus delector* (Sanders & DeLong)

Deltocephalus delector Sanders & DeLong (1919, p. 233).

Length 3.0–3.5 mm. Vertex, fig. 345B, pointed, one-fourth longer at middle than width between eyes; creamy white, with two broad tawny bands extending from base to apex, where they converge and form two black triangular spots, one on either side of white apex, and extend over the margin; a narrow black curved line extending from eye around ocellus on margin toward apex. Pronotum whitish, with four longitudinal tawny bands: one behind each eye, and a central pair, the extension of the bands on vertex; bands continuing across scutellum. Elytra tawny, with costal, sutural, and apical margins and veins white. Each elytron with a spot on inner apical cell, reflexed veinlets, and posterior white margin black bordered.

Female seventh sternite, fig. 345A, with the posterior margin sinuately sloping to form a broad shallow median notch slightly indented at center, on either side of which is a round black spot. Male plates, fig. 345C, gradually sloping to broad subtruncate apexes, inner apical third of each black, white margined. Male internal genitalia as in fig. 345D.

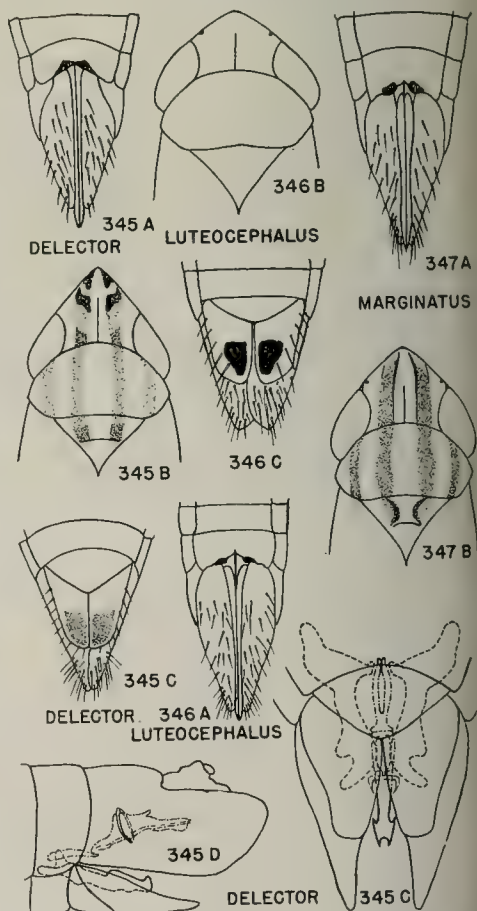
This species occurs on herbaceous plants in woodland areas and seems to be restricted to that association. It is found in the eastern part of the United States, ranging from Illinois to Maine.

Illinois Records.—OREGON: Castle Rock, June 30, 1935, DeLong & Ross, 5 ♂. WHITE PINES FOREST STATE PARK: June 30, 1935, DeLong & Ross, 5 ♂, 1 ♀.

3. *Palus marginatus* (DeLong)

Deltocephalus marginatus DeLong (1918a, p. 228).

Length 4 mm. Pale, with two longitudinal stripes. Vertex, fig. 347B, as long as basal width between eyes; two pale testaceous bands extending from apex of vertex to disc of scutellum, where they end in black spots, each band bordered interiorly by black broken lines that converge at apex; a black transverse band extending across margin of vertex and recurving on to vertex near eyes at each end. Pronotum with four longitudinal bands. Elytra pale testaceous, nervures white, heavily margined with fuscous along each claval margin and on apical portion; reflexed veinlets, posterior margins, and inner apical cells heavily marked.



Figs. 345–347.—*Palus*. A, female genitalia; B, head and pronotum; C, ventral aspect of male genitalia; D, lateral aspect of male genitalia.

Female seventh sternite, fig. 347*A*, with posterior margin sloping to a rather broad shallow U-shaped notch, slightly incised at center, a large oval black spot on each side of notch. Male unknown.

This is a fresh-water marsh species recorded from Maine, Wisconsin, and North Dakota. It occurs on either tall grasses or sedges.

54. *POLYAMIA* DeLong

Polyamia DeLong (1926*a*, p. 46).

Figs. 226, 348. Vertex rather short, bluntly angled, disc slightly convex or sloping forward, and thickly, rather bluntly

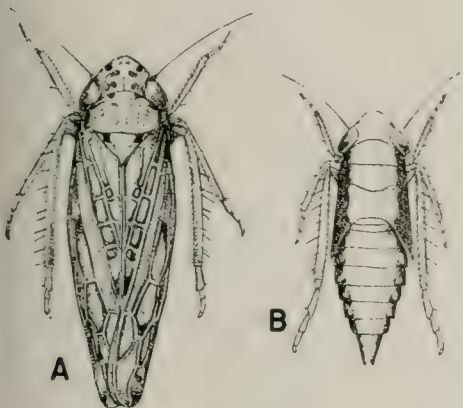


Fig. 348.—*Polyamia inimica*: *A*, adult; *B*, nymph. (From Osborn.)

angled with front. Elytra each with outer clavus strongly reticulate veined, central anteapical cell constricted and divided.

With few exceptions the species of the genus are grass feeders and frequent meadows, pastures, and prairies. Several seem to be quite restricted in food plant and habitat. About 35 species have been recorded for the United States, approximately half of which are known to occur in Illinois.

KEY TO SPECIES

1. Vertex with one or two narrow lines of recurved arcs which extend from front and are definitely visible on the dorsal curved margin of vertex, as in fig. 349*A* 2
Vertex often showing a heavy black coloring on either side of apex distinct from coloration of face, but usually without definite recurved narrow lines on margin of vertex, as in fig. 349*C* 6

2. Females 5
Males 3
3. Aedeagus, fig. 362, long, tapered to narrow tubular apex 1. *obtecta*
Aedeagus enlarged at apex, or apical portion broader than body of aedeagus, as in figs. 356, 357 4
4. Aedeagus, fig. 357, with a circular apical enlargement notched on anterior dorsal border 2. *rossi*
Aedeagus, fig. 356, with a broad rather short terminal portion bearing a curved dorsal spur, and gradually narrowed apically to a blunt tip 3. *similaris*
5. Posterior margin of seventh sternite, fig. 349*X*, rather broad, only slightly indented, forming three rather broad rounded lobes 2. *rossi*
Posterior margin narrower, indentations deeper and closer together, forming a more narrow bluntly and angularly produced lobe at center, lateral lobes narrower, figs. 349*M*, 349*V* 1. *obtecta*, 3. *similaris*
6. Vertex not marked with definite spots or bands 7
Vertex marked with spots or transverse bands or both 8
7. Entire insect pale yellowish, unmarked; elytra short, covering only first four or five segments 4. *brevipennis*
Vertex yellowish; elytra chestnut brown, with pale veins, apices broadly white 5. *apicata*
8. A pair of large round black spots on anterior margins of vertex, on pronotum, and on basal angles of scutellum, fig. 349*C* 6. *inimica*
Without three pairs of black spots arranged on anterior margin of vertex, on pronotum, and on scutellum 9
9. Vertex with a transverse fuscous band, broken at middle, or a transverse spot either side resembling an interrupted band 10
Vertex without interrupted transverse band or transverse spots 15
10. Vertex angularly produced, longer at middle than width between eyes 11
Vertex not longer at middle than width between eyes 13
11. Transverse band orange or tawny; vertex, fig. 349*D*; sharply pointed, one-fourth longer than wide; elytra heavily marked with fuscous, appearing obliquely banded 7. *arundinea*
Transverse band fuscous or brown; vertex more bluntly angled; elytra mottled, not appearing banded 12
12. Robust, 3.5 mm. in length; male plates, fig. 350, longer than pygofer, longer than combined basal width; female seventh sternite as in fig. 349*R* 8. *interrupta*
More slender, not exceeding 3.0 mm. in length; male plates, fig. 360*A*, not exceeding pygofer, less than combined basal width; female seventh sternite as in fig. 349*S* 9. *herbida*
13. Female seventh sternite, fig. 349*P*, entire, broadly and concavely excavated; male

plates, fig. 351, short, broad, apexes blunt.....10. *weedi*
Female seventh sternite with very short

lateral margins exposing lobes of underlying segments at lateral angles, as in figs. 349Q, 349U. Male plates longer,

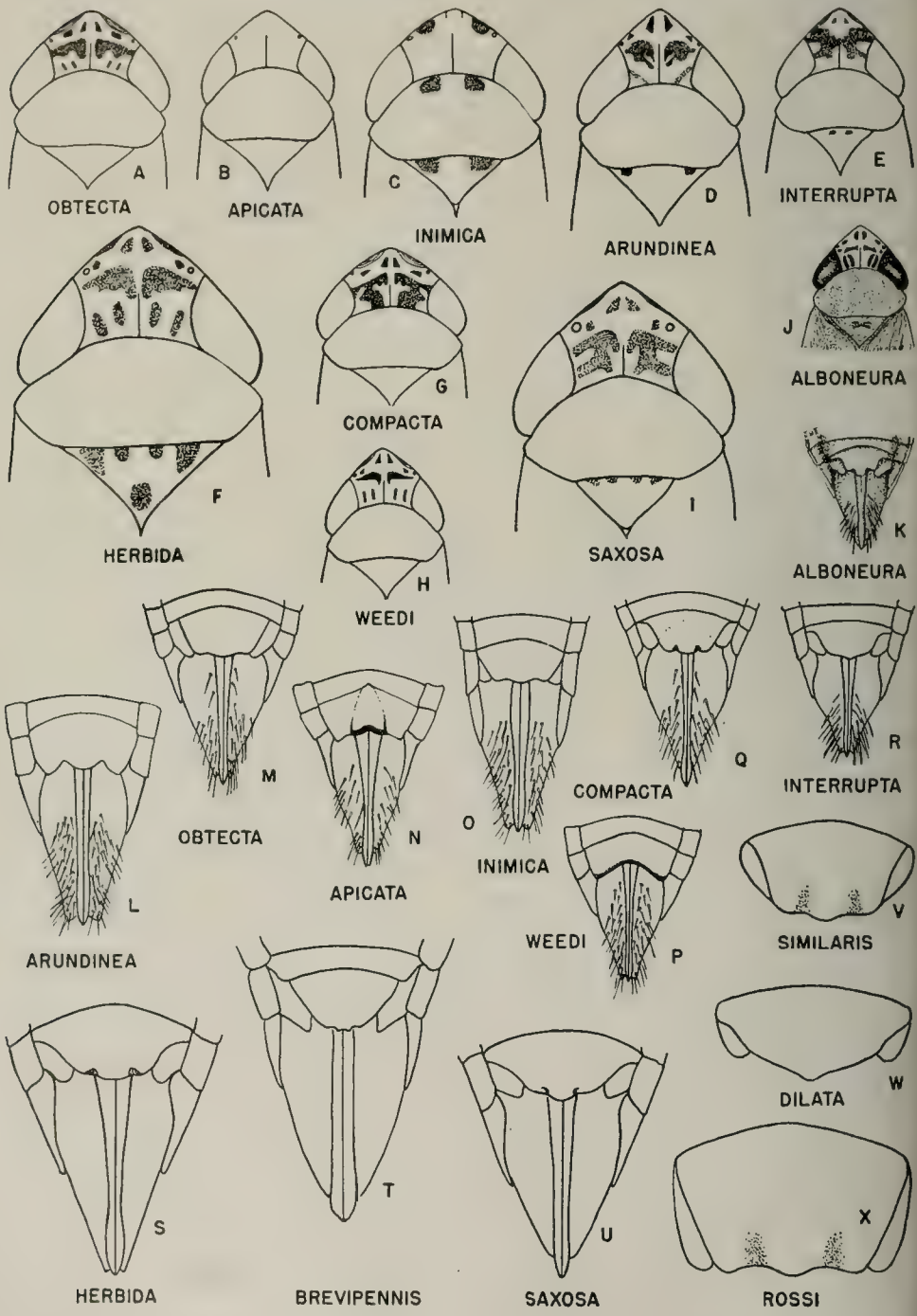


Fig. 349.—*Polyamia*. A-J, heads and thoraxes; K-X, female genitalia.

concavely rounded to acute apices, as in figs. 355, 359*A*.....14

14. Median spots on apex of vertex, fig. 349*G*, conspicuous, band dark in color; male plates, fig. 355, longer than combined basal width; female seventh sternite as in fig. 349*Q*.....11. **compacta**

Median spots of apex of vertex, fig. 349*I*, usually wanting, band faint; male plates, fig. 359, about as long as basal width; female seventh sternite as in fig. 349*U*.....12. **saxosa**

15. Length 3.5 mm.; elytra heavily infuscated, appearing obliquely banded.....7. **arundinea**

Length less than 3.0 mm.; elytra mottled, not appearing banded.....16

16. Vertex, fig. 349*J*, with a distinct row of black spots above margin.....13. **alboneura**

Spots above margin of vertex faint, the middle spots often wanting.....17

17. Yellowish, with four large faint black spots above margin; elytra infuscated.....4. **brevipennis**

Pale brownish, a small round black spot next to each ocellus, a pair of faint triangular orange spots at apex of vertex separated by white lines. Veins of elytra broadly white, heavily margined with brown.....14. **dilata**

1. *Polyamia oblecta* (Osborn & Ball)

Deltocephalus oblectus Osborn & Ball (1898, p. 78).

Length 3.0-3.5 mm. White to gray, marked with black and fuscous. Vertex, fig. 349*A*, almost one-fourth wider between eyes than median length, and whitish in color except following black or fuscous marks: reflexed arcs of face, a pair of spots just back of apex, another either side midway to eye, an irregular interrupted band, broadest at middle, between anterior margins of eyes, and an indefinite spot on either side behind band. Scutellum with a large black spot in each basal angle. Elytra with nervures broadly whitish, the cells darker, and the nervures bordered with fuscous.

Female seventh sternite, fig. 349*M*, appearing to arise abruptly from the preceding segment, not touching the pleura, produced more than twice the length of preceding segment to a truncated posterior margin; lateral lobes produced beyond median portion as rounded lobes. Male plates, fig. 362, triangular, broad at base, strongly and concavely narrowed to produced attenuated tips that are much shorter than pygofer. Aedeagus long, in lateral view appearing broadened at middle, bent caudally, and tapered to a narrow bent apex.

This is a common grass species in the eastern United States and Middle West in open grassy areas and upon the prairie.

Illinois Records.—Many males and females, taken June 13 to October 1, are from Alton, Billett, Dixon Springs, Eichorn, Fern Cliff, Fulton, Galena, Grand Detour, Hanover, Havana, Kankakee, Marshall, Oquawka, Oregon, St. Anne, Thomson, Vienna, and Watson.

2. *Polyamia rossi* DeLong

Polyamia rossi DeLong (1937*a*, p. 32).

Length 3 mm. Gray, marked with black, closely resembling *oblecta*. Vertex bluntly angled, as long at middle as basal width between eyes, with a pair of proximal pale spots, a darker spot next to either eye, and a black transverse band, which is broken at middle, between anterior margins of eyes. Thorax pale brownish, a black spot just back of each eye. Elytra white, veins bordered with brown; brown spots on middle of each clavus and disc of elytra.

Female seventh sternite, fig. 349*X*, with side margins sloping to posterior margin, which is almost truncate and dark margined; side lobes of underlying membrane conspicuous. Male plates, fig. 357, triangular, apexes rather long, tapered to acute tips. Aedeagus in lateral view long, slender on basal two-thirds, then abruptly and greatly enlarged, the ventral portion broadly curved, semicircular, with a short apical process extending dorsally and anteriorly, and a basal dorsally directed spur.

This is a rather abundant species on grasses on the sand prairie in Illinois. It is known only from this state.

Illinois Records.—AMERICA: July 16, 1937, 1 ♀. FULTON: Aug. 22, 1935, DeLong & Ross, 26 ♂, 17 ♀. THOMSON: July 4, 1936, 2 ♀; Aug. 16, 1937, 1 ♂.

3. *Polyamia similaris* DeLong & Davidson

Polyamia similaris DeLong & Davidson (1935, p. 164).

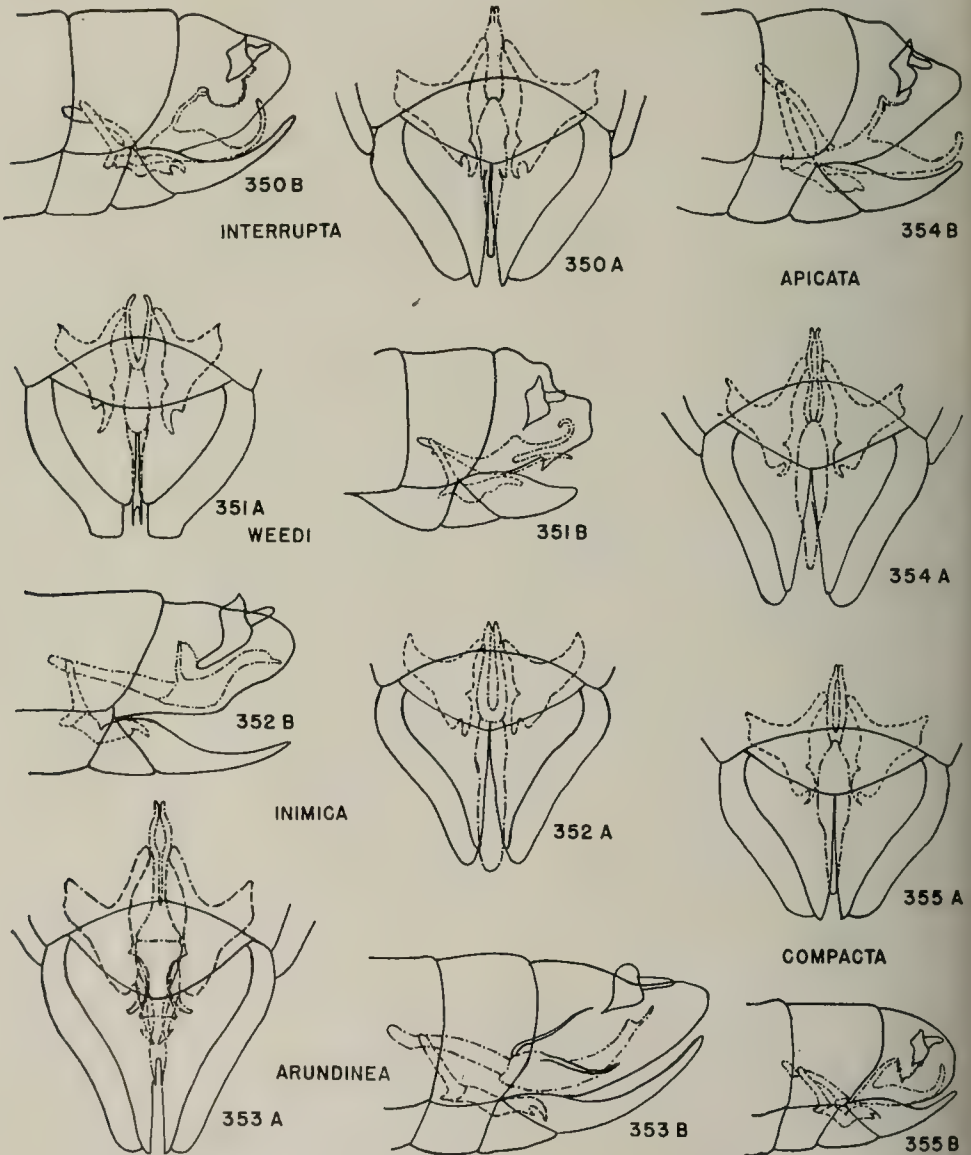
Length 3 mm. Gray, with dark markings, resembling *oblecta* in general appearance. Vertex bluntly angled, slightly wider between eyes than length at middle, with recurved arcs on either side of apex; a pair of proximal brown to black spots at apex, and one spot next to each ocellus, a broken

band between anterior margins of the eyes, and oblique markings either side on basal portion. Mottling on anterior margin of pronotum brown. Veins of elytra rather heavily infuscated.

Female seventh sternite, fig. 349*V*, produced rather abruptly on posterior margin, which is trilobate; central lobe slightly broader and not quite as long as the lateral lobes; lateral lobes of underlying membrane

conspicuous at sides of seventh sternite. Male plates, fig. 356, broad at base, short, triangular, one-third wider at base than long. Male aedeagus in normal position curved dorsally and with a dorsal curved finger-like spur.

This species is apparently southern in its distribution and has been taken in large numbers from grasses in southern Illinois. It resembles *obtecta* and *compacta* closely



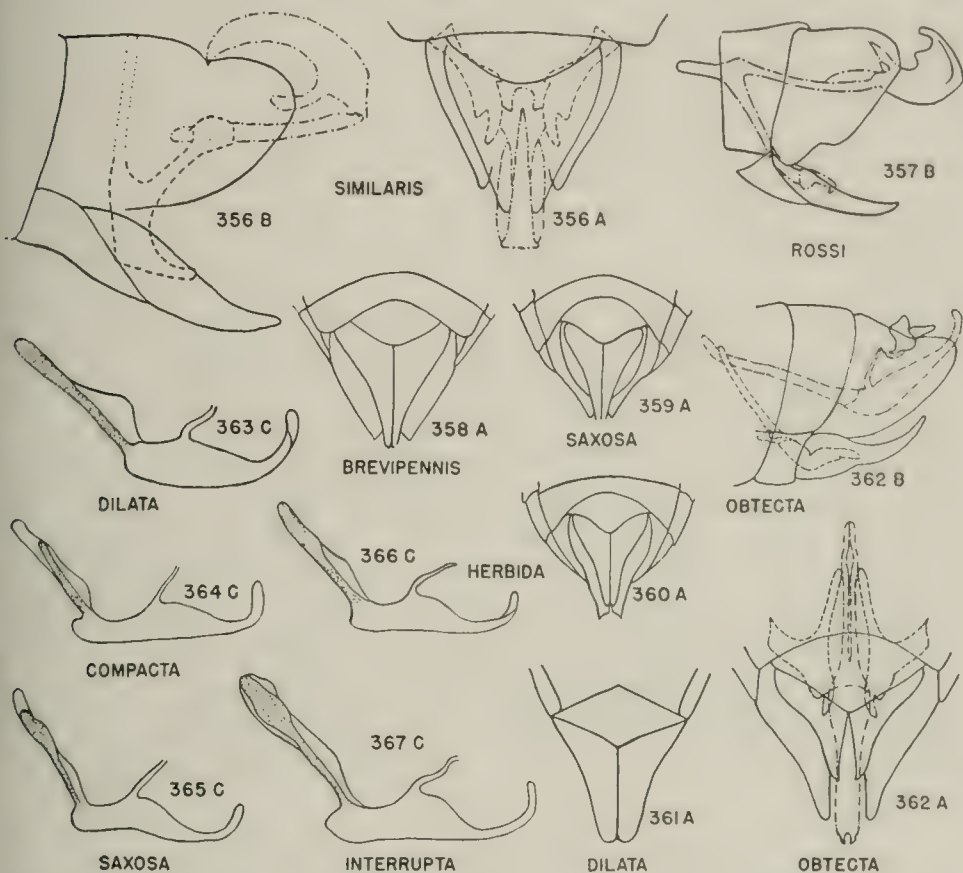
Figs. 350-355.—*Polyamia*, male genitalia. A, ventral aspect; B, lateral aspect.

and has apparently been confused with them previously.

Illinois Records.—Males and females, taken June 10 to October 3, are from Cave

spots on anterior margin of pronotum, veins of elytra heavily infuscated.

Female seventh sternite, fig. 349T, with short lateral margins; posterior margin con-



Figs. 356–367.—*Polyamia*, male genitalia. A, ventral aspect; B, lateral aspect; C, aedeagus.

in Rock, Dixon Springs, Eichorn, Fairfield, Galena, Hanover, Havana, Herod, High Knob, Luther, Marshall, Oquawka, St. Anne, Shawneetown, Vienna, and Watson.

4. *Polyamia brevipennis* DeLong & Davidson

Polyamia brevipennis DeLong & Davidson (1935, p. 164).

Length 2.0–2.5 mm. Yellowish, short-winged; vertex frequently unmarked, bluntly angled, a little longer at middle than basal width between eyes; ocelli black; dark specimens with four large faint brownish

vexily rounded, with a slight notch on either side; lateral portions of underlying membrane conspicuously produced as lobes at either side. Male plates, fig. 358A, triangularly elongate, longer than combined basal width.

This species has been taken in a prairie habitat and also in moist open wooded areas in southern Illinois. It was previously recorded from Alabama.

Illinois Records.—CAVE IN ROCK: July 9, 1935, DeLong & Ross, 1 ♀. DIXON SPRINGS: July 9, 1935, DeLong & Ross, 2 ♂, 3 ♀. ELIZABETHTOWN: July 8, 1935, DeLong & Ross, 1 ♂.

5. *Polyamia apicata* (Osborn)

Deltocephalus apicatus Osborn (1900b, p. 285).

Length 3 mm. Brown, with the head, anterior portion of pronotum, and caudal end of body pale yellow. Vertex, fig. 349B, bluntly angled, as long at middle as basal width between eyes; posterior portion of pronotum shading to brown; face often slightly darker than dorsal light areas of body; scutellum and elytra to apical transverse veins reddish brown, the nervures yellowish, apical cells yellowish hyaline.

Female seventh sternite, fig. 349N, very short at side margins, then abruptly produced, and semicircularly rounded, posterior margin bisinuate, with a brown spot on either side of middle producing trilobate appearance; underlying membrane deeply and concavely rounded, the only visible portions being the outer rounded lateral angles. Male plates, fig. 354, broad at bases, concavely rounded to narrow tips, which are produced almost the length of pygofer.

This is a very common prairie species in the eastern states and occurs on sandy areas and sand prairies on *Panicum villosissimum* and probably other species of this genus.

Illinois Records.—Males and females, taken June 12 to October 2, are from Apple River Canyon State Park, Beach, Cave in Rock, Dongola, Fern Cliff, Fulton, Galena, Geff, Grand Detour, Hanover, Harrisburg, Oquawka, St. Anne, Shawneetown, Thomson, Vienna, and Zion.

6. *Polyamia inimica* (Say)

Jassus inimicus Say (1831, p. 305).

Jassus 6-punctatus Provancher (1872, p. 378).

Length 4 mm. Grayish yellow, with a pair of black spots on vertex, pronotum, and scutellum; vertex, fig. 349C, bluntly angled, one-fourth wider between eyes than median length, a pair of minute spots at apex in addition to the pair of larger spots. Two large black spots on anterior margin of pronotum and one in each basal angle of scutellum. Elytra grayish, nervures broadly white, cells margined with fuscous.

Female seventh sternite, fig. 349O, short at lateral margins, then produced to posterior margin, which is trilobate; underlying membrane with prominent lateral angles. Male plates, fig. 352, concavely narrowed to pointed apices.

This is one of the most common species of North American leafhoppers, and is transcontinental in distribution. It is found abundantly in all types of vegetation, especially on grasses, both native and cultivated species.

Illinois Records.—Many males and females, taken May 8 to October 20, are from Aldridge, Algonquin, Alton, Amboy, Anna, Antioch, Anvil Rock, Apple River Canyon State Park, Atlas, Aurora, Barry, Beach, Bradley, Buckley, Bushnell, Cairo, Carman, Cave in Rock, Centralia, Champaign, Cornfield, Decatur, Des Plaines, Dixon Springs, Dolson, Dongola, Dubois, Duncans Mills, Eichorn, Elgin, Elizabeth, Elizabethtown, Evergreen Park, Fairfield, Forrest, Fox Lake, Fulton, Galena, Geff, Golconda, Grafton, Grand Detour, Grays Lake, Hardin, Harrisburg, Havana, Hillsboro, Ingleside, Justice, Kampsville, Kankakee, Keithsburg, Kirkwood, Lake Villa, Marshall, Mason City, Meredosia, Mokena, Momence, Monmouth, Monticello, Mount Carmel, Muncie, New Holland, Niota, Normal, Oak Lawn, Oakwood, Ogden, Onarga, Palos Park, Pecatonica, Pegrim, Plainview, Princeton, Putnam, Quincy, Rock Island, Round Lake, St. Anne, St. Joseph, Savanna, Seymour, Shawneetown, Sheffield, Sparta, Springfield, Starved Rock State Park, Summit, Taylorville, Thomasboro, Thomson, Tremont, Urbana, Ursa, Vandalia, Vienna, Virginia, Volo, Watson, Wilmington, White Heath, White Pines Forest State Park, and Zion.

7. *Polyamia arundinea* (Crumb)

Deltocephalus arundineus Crumb (1915, p. 191).

Length 3.5 mm. Pale creamy, with black spots on vertex, pronotum, and scutellum and a cross on each elytron. Vertex, fig. 349D, almost one-fourth longer at middle than width between eyes; a pair of triangular spots near apex, and a spot each side midway to eye black; a pair of large irregular fuscous spots forming a somewhat broken band between anterior margins of eyes; a pair of oblique fuscous dashes at base. Pronotum with indistinct pale longitudinal bands and a black spot behind each eye. Basal angles of scutellum and apex each with a black spot. Elytra fuscous, nervures white, margined with fuscous, three conspicuous dark spots on each elytron; one each at middle of costa, middle

of clavus, and outer apical cell, the three together suggesting a cross band.

Female seventh sternite, fig. 349L, with posterior margin trilobate, central lobe shorter, broadly rounded, on either side of which is a rounded notch. Male plates, fig. 353, long, rather strongly and concavely narrowed and produced into long acute tips.

This is one of the abundant species living on cane, *Arundinaria tecta*, and apparently is restricted to that host plant, which occurs abundantly in the southeastern United States. It is found in the southern portion of Illinois, where the cane is distributed along the streams.

Illinois Records.—DOLSON: July 24, 1936, DeLong & Mohr, 1♂. ELIZABETH-TOWN: May 27, 1931, H. L. Dozier, 1♂. HEROD: Oct. 7, 1932, Ross & Burks, 1♂, 4♀; Aug. 4, 1934, DeLong & Mohr, 6♂, 11♀; May 29, 1935, Ross & Mohr, 1♂, 1♀; June 24, 1936, DeLong & Ross, 4♂, 15♀. KARNAK: Aug. 8, 1934, DeLong, Ross, & Mohr, 1♀. THEBES: July 11, 1935, DeLong & Ross, 1♂, 8♀. ULLIN: May 26, 1932, H. L. Dozier, 1♀. VIENNA: June 14, 1934, DeLong & Ross, 41♂, 32♀; July 10, 1935, DeLong & Ross, 2♂, 5♀.

8. *Polyamia interrupta* (DeLong)

Deltocephalus interruptus DeLong (1916, p. 51).

Length 3.5–3.7 mm. Dull yellowish to brownish, with black and fuscous markings. Vertex, fig. 349E, slightly longer than basal width; two large spots at apex, sometimes joined with reflexed coloration of the face, a smaller spot on either side between these and eyes, and an irregular transverse band, broadest at middle between anterior margins of eyes, black or dark brown. Pronotum with longitudinal dark stripes. Elytra testaceous, nervures white, heavily and irregularly bordered with fuscous.

Female seventh sternite, fig. 349R, strongly and convexly produced at median two-thirds from near its base; rounded lateral lobes conspicuous at sides and produced to a line through posterior margin of seventh sternite. Male plates, fig. 350, strongly and concavely narrowed to long acute apices. Male aedeagus, fig. 367C, with basal portion slender, enlarged at about half its length to a broader portion, which is constricted to a long narrow dorsally curved apical fourth.

This species has been taken rather abundantly in open wooded areas where there is a luxuriant growth of herbaceous vegetation. It occurs in the eastern United States and is often confused with *weedi*.

Illinois Records.—Males and females, taken June 14 to September 30, are from Dixon Springs, Dolson, Dubois, Eichorn, Elizabethtown, Golconda, Herod, Karnak, Muncie, St. Anne, and Vienna.

9. *Polyamia herbida* DeLong

Polyamia herbida DeLong (1935a, p. 155).

Length 2.8–3.0 mm. Resembling *weedi* in form and coloration. Vertex, fig. 349F, bluntly angled, slightly longer at middle than width between eyes; a pair of black spots next to ocelli and a pair of proximal oblique dashes just above apex of vertex; a dark band between anterior margins of eyes and a brownish blotch on posterior portion of vertex on either side of middle. Pronotum brown, with five pale longitudinal stripes. Scutellum pale, with a dark spot in each basal angle. Elytra brownish, veins mostly dark margined; some of veins conspicuously milky white, particularly the inner vein of each clavus, crossveins of outer clavus, basal crossveins between sectors, crossveins of corium, and veins surrounding outer anteapical cell.

Female seventh sternite, fig. 349S, roundedly produced, lobes of underlying membrane conspicuous at each side. Male plates, fig. 360A, rapidly narrowed and produced in long attenuate apices. Male aedeagus, fig. 366C, very similar in form to that of *compacta*.

Described from Illinois, this species has been collected only on the sand prairie.

Illinois Records.—HANOVER: June 29, 1935, DeLong & Ross, 26♂, 21♀; sand prairie, July 10, 1934, DeLong & Ross, 4♂, 5♀; Aug. 22, 1935, DeLong & Ross, 1♀. SAVANNA: June 29, 1935, DeLong & Ross, 1♂. THOMSON: sand prairie, July 8, 1934, DeLong & Ross, 1♀.

10. *Polyamia weedi* (Van Duzee)

Deltocephalus weedi Van Duzee (1892c, p. 306).

Length 3 mm. Dull yellowish, marked with black and fuscous. Vertex, fig. 349H, bluntly angled, as long as width between eyes, with four large black spots, the central

pair, just above apex, triangular, and an irregular brown band between anterior margins of the eyes; usually some indefinite markings at base of vertex. Pronotum faintly and longitudinally striped. Scutellum with a large brown spot in each basal angle and at apex. Elytra pale brown, nervures white, bordered with fuscous, cells usually dark in color.

Female seventh sternite, fig. 349P, with posterior margin rather evenly and strongly concave. Male plates, fig. 351, short and broad, triangular, apices bluntly angled. Aedeagus in lateral view appearing incised at apex more than half way to base, the dorsal portion curved dorsally and anteriorly at apex.

This is a very common grass-feeding species in the eastern half of the United States and is probably the most common species of the genus with the exception of *inimica*. It is commonly found in meadows, pastures, and other grassy areas.

Illinois Records.—Many males and females, taken June 10 to October 3, are from Aldridge, Alton, Anna, Apple River Canyon State Park, Brownfield, Browns, Bluff Springs, Cave in Rock, Dixon, Dixon Springs, Dolson, Dongola, East St. Louis, Eichorn, Elizabethtown, Fern Cliff, Fox Lake, Fulton, Galena, Gibsonia, Grand Detour, Grand Tower, Hanover, Havana, Herod, High Knob, Karnak, La Rue, Marshall, Monticello, Mount Carmel, Muncie, Newton, Oakwood, Oregon, Ripley, Rock Island, Shawneetown, Springfield, Starved Rock State Park, Thomson, Urbana, Vandalia, Vienna, White Heath, and White Pines Forest State Park.

11. *Polyamia compacta* (Osborn & Ball)

Deltocephalus compactus Osborn & Ball (1897, p. 217).

Length 2.75 mm. Yellowish, vertex, fig. 349G, marked somewhat similarly to that of *weedi*, bluntly angled, one-fourth wider between eyes than length at middle; black line from face visible from above, the four spots behind anterior margin and the transverse band between eyes fuscous. Elytra tawny to fuscous, some of the nervures broadly white, most cells heavily margined with fuscous.

Female seventh sternite, fig. 349Q, very short at lateral margins, then strongly and

roundedly produced on median two-thirds, forming a slightly trilobate posterior margin; underlying membrane deeply and circularly emarginate, visible only as acute lateral angles at the sides of the seventh sternite. Male plates, fig. 355, broad at bases, rapidly and concavely narrowing and produced to long attenuated tips, which exceed the pygofer. Aedeagus as in fig. 364C.

This is a very short robust species common in grassy areas and frequently abundant in hillside pastures or on prairies. It is distributed through the eastern United States and occurs as far west as the states of Iowa and Kansas.

Illinois Records.—METROPOLIS: Aug. 18, 1891, 2♂, 1♀; Aug. 19, 1891, Shiga & Hart, 1♂. PARKER: Aug. 14, 1909, 2♀. ZION: Aug. 7, 1935, Ross & DeLong, 16♂, 21♀.

12. *Polyamia saxosa* DeLong

Polyamia saxosa DeLong (1935a, p. 156).

Length 2.5–2.7 mm. Closely related to *compacta*. Vertex, fig. 349I, bluntly angled, about as wide between eyes as median length, pale straw yellow, with a pair of brownish quadrate spots, one next to either eye, and a pair of pale, orange, triangular spots at apex, an interrupted brownish band between anterior margins of eyes, and a dark area on posterior portion on either side of middle. Pronotum with dark spots on anterior portion. Scutellum pale, with a brown spot at apex. Elytra straw to pale brown; veins broadly white, with brown areas on apical, costal, and discal cells; each clavus white, with two brown elongated cells.

Female seventh sternite, fig. 349U, with side margins short, gradually sloping to broadly rounded posterior margin, which is slightly indented on either side of a median rounded lobe. Male plates, fig. 359, long, tapering to acute tips. Male aedeagus, fig. 365C, with apical constricted portion longer than in *compacta*, but otherwise very similar.

This species was taken from small grasses and herbaceous plants in a prairie habitat in Illinois and has not been recorded outside of this state.

Illinois Record.—APPLE RIVER CANYON STATE PARK: July 11, 1934, DeLong & Ross, 6♂, 1♀.

13. *Polyamia alboneura* (DeLong)

Deltocephalus alboneura DeLong (1918b, p. 236).

Length 2.0–2.5 mm. Closely related to *apicata* but with black markings on vertex and with a more produced head. Vertex, fig. 349J, one-fourth longer at middle than basal width between eyes, pale yellow, with ocelli and four quadrate spots above margin black; a pair of transverse dashes between margins of eyes and a pair of oblique dashes on either side at base of vertex black or fuscous. Pronotum black, with five yellowish longitudinal stripes. Scutellum and elytra black, veins pale yellow. Face yellow, venter dark.

Female seventh sternite, fig. 349K, with posterior margin produced and appearing trilobate; visible portions of underlying membrane conspicuous as rounded lateral angles. Male plates concavely rounded to narrow tips, which are strongly produced.

Found in small numbers in grassy habitats, especially under humid conditions, this species is recorded from Mississippi, Tennessee, and the southern part of Illinois.

Illinois Records.—ELIZABETHTOWN: July 8, 1935, Ross & DeLong, 2♂. HEROD: July 6, 1935, DeLong & Ross, 3♂, 3♀. VIENNA: June 14, 1934, DeLong & Ross, 1♀.

14. *Polyamia dilata* DeLong

Polyamia dilata DeLong (1937a, p. 33).

Length 2.5–2.75 mm. Gray, resembling *compacta* in general appearance. Vertex bluntly angled, a little longer at middle than basal width between eyes; whitish in color, ocelli and an interior mesal spot black; a pair of proximal triangular spots just above apex pale brown, or orange; indications of a pale orange band at anterior margin of eyes and a pair of oblique marks each side at base; face dark, with pale arcs above. Pronotum brown, with pale longitudinal stripes. Scutellum pale brown. Elytra pale brown, veins broadly white, heavily margined with dark brown.

Female seventh sternite, fig. 349H, broadly and roundedly produced, with a slightly produced rounded lobe on central fourth; lateral lobes of underlying sternite conspicuous. Male plates, fig. 361J, long, concavely narrowed to acutely pointed

apexes. Aedeagus in lateral view, fig. 363C, with the body rather broad, scarcely narrowed anteriorly, posteriorly narrowed gradually to form a long apical third that is produced and curved caudally.

Occurring on prairie grasses in restricted habitats, this species has been taken in Illinois at only one locality, and is known only from Illinois.

Illinois Record.—APPLE RIVER CANYON STATE PARK: Aug 22, 1935, Ross & DeLong, 16♂, 18♀.

55. *DELTOCEPHALUS* Burmeister

Deltocephalus Burmeister (1838, pl. 14).

Vertex rather short, usually roundedly produced or bluntly angled, disc sloping or convexly rounding from pronotum to front, or with margin thick, scarcely angled with front. Ocelli close to the eyes and distinctly below the level of the disc. Venation of elytra simple, each central anteapical cell elongate, constricted, and usually divided.

The group of species in this genus can usually be recognized by the black coloration on the vertex in the form of spots, bars, and bands, which in some cases extend down along the eyes on the face, and by numerous heavy black arcs or bars on the face. The female seventh sternite is usually concave and frequently bears a sunken tooth.

About 35 species of *Deltocephalus* have been recorded for the United States; of these 7 are known to occur in Illinois. One or more others may eventually be found here.

KEY TO SPECIES

1. Color uniform smoky brown, without definite markings; length 4.5 to 5.0 mm. **1. fumidus**
Not uniformly smoky brown, either black and usually with pale markings, or some shade of green or yellow; length not exceeding 3.5 mm. 2
2. Black in color or heavily marked with black or dark brown. 3
Green or yellowish, marked with black spots or bands. 4
3. Dark brown to black, with several white spots on vertex, fig. 368C; anterior half of costal margins of elytra broadly yellow; length 3.0 mm. or more
..... **2. flavicostus**
Black, shiny, with few pale spots; costal margin not marked with yellow; length not more than 2.5 mm. **3. gnarus**
4. Vertex with a broken band between anterior margins of eyes. 5
Vertex without a broken band between

- anterior margins of eyes, a row of spots above margin.....8
5. With two small spots above apex of vertex.....6
- With a row of four spots above apex, fig. 368D.....7. **balli**
6. Band of vertex narrow, with an anterior projection at each end on inside margin of ocellus; body pale beneath.....7
- Band of vertex, fig. 368F, broad, irregular in outline, usually with a posteriorly projecting mark near each eye; body black beneath.....4. **nigriventer**
7. Elytra yellow, without dark markings....5. **caperatus**

Elytra pale, heavily infuscated.....6. **gramus**

8. Median spots of vertex, fig. 368A, usually merged, forming a larger transverse marking just above apex....9. **decisus**
- Median spots not merged or proximal, distinctly separated at middle.....9
9. Vertex with four black spots above margin, the median pair smaller and approximate; two pairs of oblique dashes on base.....8. **sonorus**
- Vertex spots on margin, fig. 368D, larger, the outer spots usually elongate; oblique spots on base of vertex.....7. **balli**

1. *Deltocephalus fumidus* Sanders & DeLong

Deltocephalus fumidus Sanders & DeLong (1917 p. 86).

Length 4.5–5.0 mm. Smoky brown, iridescent in color. Vertex, fig. 368E, bluntly angled, a little wider between eyes than length at middle, smoky, darker at apex, ocelli black, encircled with white. Elytra pale brown, nervures paler, narrowly brown margined.

Female seventh sternite, fig. 374C, with posterior margin truncate, slightly sinuate, and infuscated either side of middle; underlying membrane with prominent lobes visible at side of seventh sternite. Male plates, fig. 374A, long, broad at base, and concavely narrowed to pointed apices.

This species has been collected only in southern Wisconsin but it should eventually be found in northern Illinois.

2. *Deltocephalus flavicostus* Stål

Deltocephalus flavicostus Stål (1859, p. 53).
Deltocephalus flavocostatus Van Duzee (1892b, p. 116).
Deltocephalus retrorsus Uhler (1895, p. 78).

Length 3.0–3.5 mm. Dark brown to black, with costal margins of elytra yellowish. Vertex, fig. 368C, roundedly conical, wider between eyes than median length, with a pale spot enclosing each ocellus, a pale spot at tip of apex, three pale spots arranged concentrically behind apex, and pale spots at the base. Pronotum with faint traces of pale longitudinal lines. Elytra with veins usually paler, the anterior half of each costa usually broadly yellow, and the costal veinlets on posterior portion broadly white. Face black.

Female seventh sternite, fig. 369C, with posterior margin sinuate, forming four rather distinct lobes, the inner pair nar-

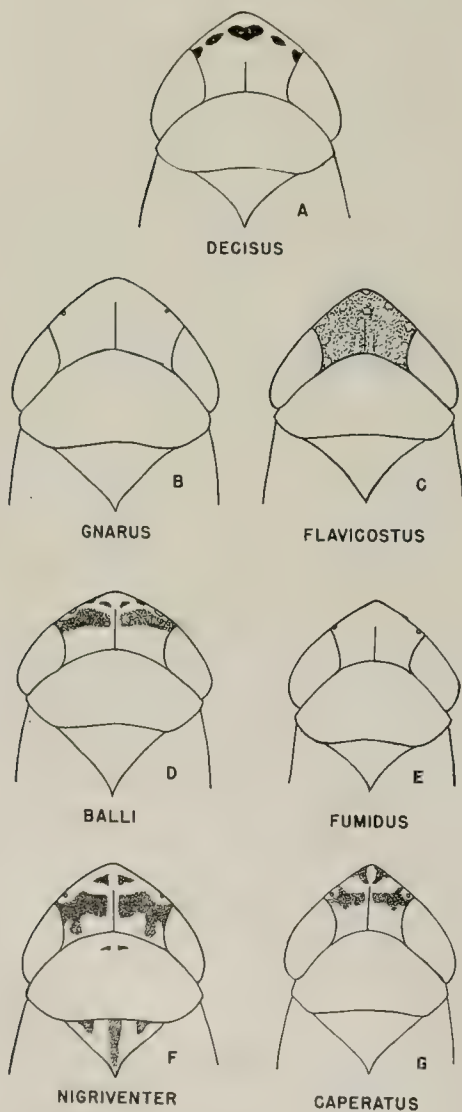
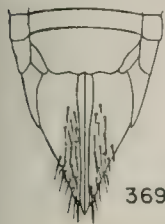


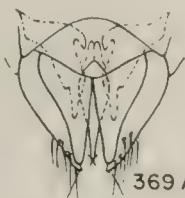
Fig. 368.—*Deltocephalus*. A–G, heads and pronota.

rower; lobes of underlying membrane visible at the sides. Male plates, fig. 369, gradually narrowed to blunt rounded tips.

Aedeagus with a dorsal spur at base, body curved dorsally, constricted on apical third, apex bluntly pointed.



369 C



369 A



369 B

FLAVICOSTUS

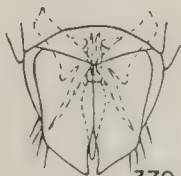


374 C

FUMIDUS

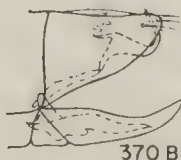


370 C



370 A

NIGRIVENTER



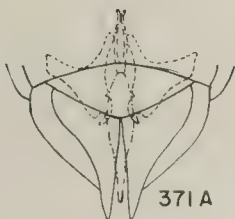
370 B



374 A

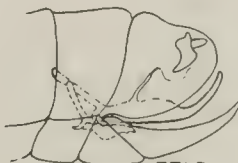


371 C



371 A

CAPERATUS



371 B



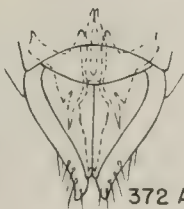
375 C

GNARUS

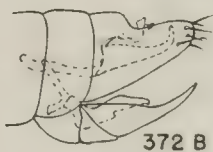


372 C

BALLI

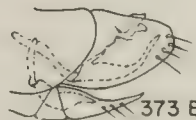


372 A



372 B

BALLI



373 B

SONORUS

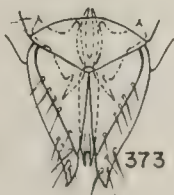


375 A

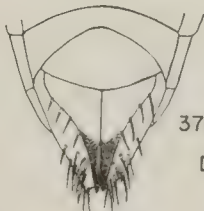


373 C

SONORUS

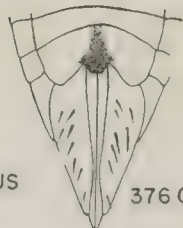


373 A



376 A

DECISUS



376 C

Figs. 369-376.—*Deltoccephalus*. A, ventral aspect of male genitalia; B, lateral aspect of male genitalia; C, female genitalia.

This is a common grass-feeding species in the East and Middle West and occurs abundantly in almost every grassy area, especially in meadows and pastures.

Illinois Records.—Many males and females, taken from May 25 to November 4, are from Aldridge, Alto Pass, Amboy, Anna, Anvil Rock, Brownfield, Cave in Rock, Champaign, Clay City, Cobden, Decatur, Dixon Springs, Dolson, Dongola, Eichorn, Elizabethtown, Fern Cliff, Fountain Bluff, Fulton, Grand Detour, Grand Tower, Hardin, Harrisburg, Jonesboro, Karnak, Macomb, Marshall, Metropolis, Mount Carmel, Muncie, Normal, Oak Lawn, Oakwood, Pekin, Port Byron, Quincy, Shawneetown, Sparta, Springfield, Temple Hill, Urbana, Vandalia, Vienna, Villa Ridge, Virginia, and Watson.

3. *Deltocephalus gnarus* Ball

Deltocephalus gnarus Ball (1900c, p. 345).

Length 2.25–2.5 mm. Minute, shiny black. Vertex, fig. 368B, blunt, one-fourth wider between eyes than median length, a pale spot at apex often connected to a cross back of it, and sometimes connecting by lines to the circles around ocelli; a pair of pale oblique dashes from margin toward disc. Pronotum with a row of light submarginal spots, and with the posterior margin narrowly light. Scutellum black. Elytra white, subhyaline, veins milky; in the male the disc of each elytron is often smoky. Face black, with numerous dashes and pale arcs.

Female seventh sternite, fig. 375C, with posterior margin almost truncate; central fourth slightly indented, bearing a very minute blunt tooth at center; membranous plates exposed at sides of seventh sternite. Male plates, fig. 375A, slightly and roundly narrowed to pointed tips.

This is a minute species known previously from Iowa, South Dakota, and Tennessee. It closely resembles *Macrosteles potoria*, and the two species occur together on *Eleocharis* and similar aquatic plants. It has been taken in Illinois only in the central and northern parts of the state.

Illinois Records.—BEACH: July 25, 1934, Frison & DeLong, 2♀. CHAMPAIGN: Sept. 20, 1886, C. A. Hart, 1♀. OAK LAWN: July 1, 1935, DeLong & Ross, 26♂, 21♀. URBANA: May 27, 1889, C. A. Hart, 1♂.

4. *Deltocephalus nigriventer* Sanders & DeLong

Deltocephalus nigriventer Sanders & DeLong (1917, p. 85).

Length 2.5–2.75 mm. Yellow, robust, with dark markings. Vertex, fig. 368F, about two-thirds as long as basal width between eyes; yellow, with a pair of apical black spots just back of apex, and a broad sinuate black band, interrupted at middle, between anterior margins of eyes and ocelli. Pronotum pale; scutellum, spots in basal angles, and a median longitudinal stripe black. Elytra milky gray, subhyaline, each clavus irregularly mottled with brown; a large black spot on each discal cell; one on third anteapical cell, and another midway on costal margin. Nervures milky white. Face and venter black.

Female seventh sternite, fig. 370C, with posterior margin almost truncate and incised at middle almost to the base, the margins of incision almost overlapping. Male plates, fig. 370, broadly convex, tapering to rounded upturned blunt apices. Aedeagus short, rapidly tapered on basal half to a slender tapered upturned apical half, which is sharp pointed.

A northern species occurring in old pastures on grasses, *nigriventer* will probably be found in northern Illinois.

5. *Deltocephalus caperatus* Ball

Deltocephalus caperatus Ball (1900c, p. 343). *Deltocephalus vinnulus* Crumb (1915, p. 192).

Length 3 mm. Pale yellow, with black markings. Vertex, fig. 368G, bluntly angled, about as long at middle as width between eyes, with black markings from the front extending on to vertex and forming a triangular spot on either side of apex, and a broken transverse black band between anterior margins of eyes. Elytra olive, subhyaline, veins whitish, sometimes narrowly fuscous margined. Face black above, with pale arcs, a black band along apex on the front.

Female seventh sternite, fig. 371C, with lateral margins short, lateral angles rounded to posterior margin, which is bisinuate, forming three lobes, the central one smallest; membranous lateral angles visible. Male plates, fig. 371, concavely narrowed and produced to gradually tapering acutely angled apices.

This species is commonly found in the *Andropogon virginicus* association, and apparently feeds on that plant. It is distributed through the eastern half of the United States and ranges west to Colorado.

Illinois Records.—APPLE RIVER CANYON STATE PARK: Aug. 22, 1933, DeLong & Ross, 1 ♀; July 11, 1934, DeLong & Ross, 4 ♂, 3 ♀. DIXON SPRINGS: July 9, 1935, DeLong & Ross, 1 ♀. EVERGREEN PARK: Aug. 23, 1934, DeLong & Ross, 1 ♂, 2 ♀. FERN CLIFF: Aug. 3, 1934, DeLong & Mohr, 2 ♀.

6. *Deltocephalus gramus* (DeLong)

Polyamia grama DeLong (1935a, p. 156).

Length 2.3 mm. Yellowish, with black markings. Vertex bluntly angled, longer than basal width between eyes; a pair of large spots just back of apex; a broad transverse black band, broken at middle, extending between anterior margins of eyes; a portion of band arises at outer end and extends anteriorly, surrounding the ocelli; posterior half of vertex dark. Pronotum dark, marked with heavy black spots on anterior half. Elytra pale brown, veins lighter, margined with heavy brown infuscations; elytra appearing longitudinally striped. Face with a prominent curved marginal band just below vertex, extending down either side of face, and arcs of face dark brown.

Male plates rather broad at bases, rapidly narrowed to finger-like apices, which are greatly produced and acutely pointed.

Only two male specimens of this species are known, and these were taken in northern Illinois on grasses in prairie habitats.

Illinois Records.—APPLE RIVER CANYON STATE PARK: Aug. 27, 1934, Frison & DeLong, 1 ♂. CHICAGO: Sept. 16, 1930, D. M. DeLong, 1 ♂.

7. *Deltocephalus balli* Van Duzee

Deltocephalus nigrifrons Van Duzee (1894c, p. 293). Name preoccupied.

Deltocephalus balli Van Duzee (1916, p. 71). New name.

Length 3.0–3.5 mm. Yellow to greenish, marked with black spots. Vertex, fig. 368D, bluntly angled, almost one-third wider between eyes than median length, usually with four spots above the front margin; the inner pair of spots may vary in size and

the outer pair are often short bands extending from margins of the eyes and interrupted at the middle. Pronotum usually pale anteriorly and darker posteriorly. Elytra smoky or olive subhyaline, nervures paler. Face black, with pale arcs.

Female seventh sternite, fig. 372C, with posterior margin sinuately sloping to a slightly excavated central portion that bears a minute black tooth at its apex; membranous lobes conspicuous at sides of segments. Male plates, fig. 372, broad at bases, convexly rounded to blunt tips, which equal or surpass pygofers. The aedeagus is short, gradually narrowed to a blunt upturned tip.

This species is abundant in meadows and pastures, and is commonly found throughout the northeastern United States.

Illinois Records.—Many males and females, taken from March to October 16, are from Albion, Algonquin, Alsip, Antioch, Beach, Dixon, Duncans Mills, Fox Lake, Fulton, Galena, Grafton, Gulfport, Havana, Homer, Karnak, Luther, McHenry, Mount Carmel, Muncie, Oak Lawn, Oquawka, Pere Marquette State Park, Port Byron, Putnam, Savanna, Sheffield, Summit, Urbana, Vienna, Volo, Watson, Wauconda, Waukegan, and Zion.

8. *Deltocephalus sonorus* Ball

Deltocephalus sonorus Ball (1900c, p. 344).

Length 3.25 mm. Slender, green to yellowish, marked with black spots. Vertex rounded at apex, one-fourth wider between eyes than median length, with four black spots on the anterior margin; inner pair usually quadrate and smaller than outer; usually a pair of elongate fuscous spots on either side of middle at base, and a pair on disc. Pronotum with five yellowish longitudinal stripes. Elytra olive to yellowish, subhyaline, veins pale, often margined with fuscous.

Female seventh sternite, fig. 373C, with posterior margin slightly excavated and with a short produced rounded median lobe. Male plates, fig. 373, broad at bases, gradually narrowed to acute tips. Aedeagus rather short, curved dorsally on apical third, narrowed, and with a bluntly pointed apex.

This species occurs upon grasses and many cultivated crops, for example, wheat, clover, and alfalfa, and it can be found in abundance in pastures, meadows, and other open

habitats where grasses are common. It is widely distributed from Florida through the Middle West to Arizona and California.

Illinois Records.—ALTON: June 26, 1934, DeLong & Ross, 2 ♀. AMBOY: Aug. 8, 1934, DeLong & Ross, 1 ♀. EVERGREEN PARK: Aug. 23, 1934, DeLong & Ross, 1 ♂. GIBSONIA: Oct. 2, 1934, Frison & Ross, 1 ♀. HAVANA: Aug. 8, 1934, Frison & Mohr, 3 ♂, 8 ♀. OQUAWKA: July 30, 1936, Mohr & Burks, 1 ♀. VIENNA: on cane, June 14, 1934, DeLong & Ross, 1 ♀.

9. *Deltocephalus decisus* DeLong

Deltocephalus decisus DeLong (1926a, p. 55).

Length 2.5 mm. Straw yellowish, with black spots. Vertex, fig. 368A, as long at middle as basal width, the sides convexly rounded, with a large black transverse spot just behind apex, this spot sometimes divided into two separate spots; also an elongated black spot on either side along margin midway to eye and a smaller one next to each eye; margin of vertex milky white between this row of spots and a heavy black band on front just below margin. Elytra brownish yellow, subhyaline, nervures paler. A black spot on last dorsal tergite of both sexes.

Female seventh sternite, fig. 376C, with posterior margin broadly and angularly excavated one-third the distance to base and bearing a broad blunt tooth at apex. Male plates, fig. 376A, broad at bases, concavely narrowed and produced into long blunt processes, these black on either apical half.

This is another grass-feeding species that is not found abundantly but seems to occur in moist habitats on short grasses. It was previously recorded from Florida only, and has been taken in southern Illinois.

Illinois Records.—SHAWNEETOWN: June 23, 1936, DeLong & Ross, 1 ♂. VIENNA: June 14, 1934, DeLong & Ross, 1 ♂, 1 ♀.

56. *LONATURA* Osborn & Ball

Lonatura Osborn & Ball (1898, p. 83).

Fig. 203. Head conically and obtusely angled, pronotum with posterior margin truncate. Macropterous form with long narrow elytra, appendix large, venation obscure. Brachypterous form with short elytra, covering second abdominal segment; wings rudimentary, venation obscure.

The species of this genus are grass-feed-

ing forms and as far as known live in prairie habitats or upland pastures and meadows. Eleven species and one variety are known to occur in the United States, and one of these has been taken in Illinois.

1. *Lonatura catalina* Osborn & Ball

Lonatura catalina Osborn & Ball (1898, p. 83).

Length of macropterous form 2.75 mm.; brachypterous 1.8–2.25 mm. Vertex about as long as basal width. Macropterous form greenish gray, vertex tinted with yellow; eyes black. Brachypterous form, fig. 238C, uniform creamy white or orange in color, vertex and face often yellow; pronotum and elytra brown, and abdomen almost black.

Female seventh sternite emarginate posteriorly, with a bilobed process. Male plates small, triangular, apices produced.

In the Middle West this is a very abundant species in the *Aristida gracilis* association, and is frequently found on hillside pastures or in areas that have been denuded and where *Aristida* is the pioneer vegetation. It also occurs in sand prairies and certain of the more moist prairies.

Illinois Records.—CAVE IN ROCK: Oct. 2, 1934, Frison & Ross, 1 ♂, 2 ♀. HARDIN: June 27, 1934, DeLong & Ross, 43 ♂, 39 ♀. HEROD: July 8, 1935, DeLong & Ross, 1 ♀.

57. *HEBECEPHALUS* DeLong

Hebecephalus DeLong (1926a, p. 58).

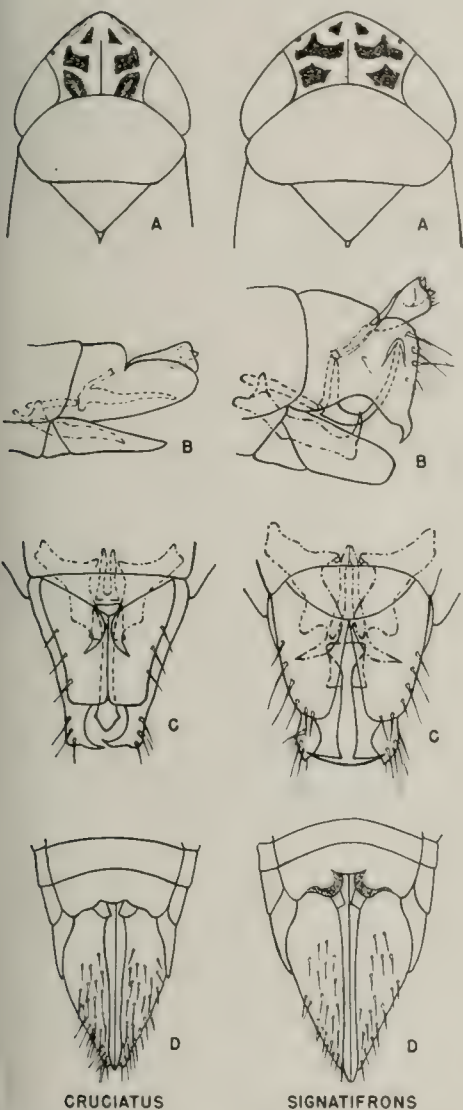
Fig. 227. Vertex bluntly angled, disc usually flattened, margin thickened and bluntly angled with front. Elytra usually rather long, central anteapical cell of each elongated, strongly constricted at middle, enlarged at either end, and decidedly produced beyond the other anteapical cell.

More than 30 species of *Hebecephalus* have been recorded for the United States, nearly all of which occur in the West. Only two of these species are found in the East, and they have been collected in Illinois.

KEY TO SPECIES

1. Vertex wider than long; female seventh sternite, fig. 377D, with a deep narrow abrupt excavation at center; male plates, fig. 377C, broad, shorter than combined width at base, apices truncate. 1. *signatifrons*
Vertex as long as wide; female seventh sternite, fig. 377D, sinuate or truncate, not excavated; male plates, fig. 377C,

as long as combined basal width, more narrowed, wedge shaped. 2. *cruciatu*s



CRUCIATUS

SIGNATIFRONS

Fig. 377.—*Hebecephalus*. A, head and pronotum; B, male genitalia, lateral aspect; C, male genitalia, ventral aspect; D, female genitalia.

1. *Hebecephalus signatifrons* (Van Duzee)

Deltocephalus signatifrons Van Duzee (1892c, p. 305).

Length 3.0–3.5 mm. Pale yellow to gray, with fuscous markings. Vertex, fig. 377A, bluntly angled, about one-third wider be-

tween eyes than length at middle; ocelli, a pair of marginal dashes close to apex, a pair of large rectangular spots behind these, each with a spur extending to margin, and a pair of large round spots on base fuscous. Pronotum with traces of five pale longitudinal stripes. Elytra gray, nervures pale, margined with fuscous, often appearing banded by heavy fuscous markings.

Female seventh sternite, fig. 377D, with posterior margin shallowly and concavely rounded between prominent lateral angles and a pair of large rounded median lobes; lobes separated by a square notch extending almost half way to the base; at the bottom of notch a broad tooth is slightly produced. Male plates, fig. 377C, broad at bases, gradually narrowed to very broad rounded apices. Aedeagus, fig. 377B, with a pair of apical spines directed laterally.

This species, which is western and middle western in distribution, occurs commonly on grasses and herbaceous vegetation. It has been reported as living in the *Setaria-Panicum* association.

Illinois Records.—Males and females, taken May 30 to September 20, are from Apple River Canyon State Park, Beach, Decatur, Dixon, Fulton, Grand Tower, Herod, Homer, Karnak, Muncie, Seymour, Springfield, Starved Rock State Park, Summit, Urbana, Wauconda, and Zion.

2. *Hebecephalus cruciatus* (Osborn & Ball)

Deltocephalus cruciatus Osborn & Ball (1898, p. 77).

Length 2.75–3.0 mm. Pale gray, resembling *signatifrons* but smaller. Vertex, fig. 377A, bluntly angled, length equaling basal width between eyes. Frontal arcs extending over margin, a pair of fuscous triangular spots just back of apex, two irregular fuscous oblique spots between ocelli, and a pair of fuscous spots on each side at base. Pronotum with five pale longitudinal stripes. Scutellum with four small spots along anterior margin. Elytra whitish, nervures pale, margined with fuscous, a few cells often quite dark.

Female seventh sternite, fig. 377D, with posterior margin slightly concave and sinuate. Male plates, fig. 377C, broad at base, gradually narrowed to truncate tips, which are one-half as wide as at base. Aedeagus in lateral view, fig. 377B, tapered to a nar-

row apex; in ventral view widened just before apex and bluntly pointed.

This species, reported previously from North Dakota and Iowa, occurs on prairie plants in the prairie habitat.

Illinois Records.—**DECATUR:** June 29, 1935, Frison & Mohr, 1 ♀. **FULTON:** Aug. 22, 1935, DeLong & Ross, 2 ♂, 8 ♀. **HANOVER:** sand prairie, July 10, 1934, DeLong & Ross, 1 ♂, 1 ♀; June 29, 1935, DeLong & Ross, 10 ♀; Aug. 22, 1935, DeLong & Ross, 7 ♂, 8 ♀. **ST. ANNE:** July 20, 1934, DeLong & Ross, 2 ♂, 1 ♀. **THOMSON:** July 8, 1934, DeLong & Ross, 5 ♂, 2 ♀; June 30, 1935, DeLong & Ross, 21 ♀; Aug. 16, 1937, 1 ♀. **ZION:** July 16, 1935, DeLong & Ross, 1 ♀.

58. *LAEVICEPHALUS* DeLong

Laevicephalus DeLong (1926a, p. 64).

Vertex varying from a sharply angled and pointed type, the vertex acutely angled with front, to a rather bluntly angled type with sides often rounding to apex, and with vertex bluntly angled with front. Vertex flattened on disc. Venation simple.

With few exceptions the species belonging to this genus are some shade of green or yellow, quite uniform in color, and without dark markings.

About 60 species of *Laevicephalus* have been described for the United States, 9 of which are known to occur in Illinois. As far as is known, practically all of them are grass feeders and are usually found in pastures and meadows.

KEY TO SPECIES

1. Vertex longer than basal width between eyes, usually distinctly angled and pointed, occasionally with tip more blunt.....2
- Vertex broader between eyes than length at middle, or, if as long, then with apex roundedly pointed, not sharply angled.....7
2. Length not more than 3.0 mm.....3
- Length more than 3.5 mm.....5
3. Dull yellowish, with two broad longitudinal brown stripes extending across pronotum to scutellum.....1. *shingwauki*
- Greenish or greenish yellow, with definite dark markings.....4
4. Female seventh sternite, fig. 386E, narrowly incised at middle, a round black spot on either side. Male plates, fig. 382A, convexly rounded, almost as long as pygofers, apices angled.....2. *minimus*

- Female seventh sternite, fig. 386H, with a broad shallow excavation; male plates, fig. 381, shorter, apices broadly rounded, almost truncate.....3. *melsheimerii*
5. Female seventh sternite, fig. 386G, sinuate, with three small lobes at center; male plates, fig. 379, tapered and abruptly narrowed to narrow attenuated apices.....4. *unicoloratus*
 - Female seventh sternite distinctly produced at center, as in fig. 386I; apices of male plates not attenuated, but narrowed and pointed.....6
 6. Female seventh sternite, fig. 386I, with median third abruptly produced and truncated. Male plates, fig. 383, with tips quite broad, bluntly pointed and divergent.....5. *syvestris*
 - Female seventh sternite, fig. 386A, with median half gradually produced to a pointed brownish tooth. Male plates, fig. 378, tapered to narrowly rounded tips.....6. *acus*
 7. Greenish, with two parallel brownish stripes on vertex, on pronotum, and on scutellum.....7. *concinus*
 - Greenish, without parallel brownish stripes.....8
 8. Female seventh sternite, fig. 386F, produced and incised at middle; male plates, fig. 385, strongly and convexly rounded to broad blunt apices.....8. *orientalis*
 - Female seventh sternite, fig. 386B, produced but not incised; male plates, fig. 380, narrowed to pointed apices.....9. *pravus*

1. *Laevicephalus shingwauki* Beamer & Tuthill

Laevicephalus shingwauki Beamer & Tuthill (1934, p. 19).

Length 2.5–3.0 mm. Dull yellow, with black markings. Vertex slightly longer than width between eyes, with two dark almost parallel broad stripes extending across pronotum to scutellum. Elytra somewhat smoky. Male and female with two large black spots on last abdominal segment, spots of female smaller. Female seventh sternite, fig. 386D, with posterior margin produced at middle into a broad tooth. Male plates, fig. 384A, broad at bases, slightly converging to broad truncate apices. Male aedeagus, fig. 384B, short, broad, cylindrical, a narrow process arising on dorsocaudal margin, bifurcate near its base, the two processes long, curved laterally and ventrally.

This is an abundant species in the freshwater marshes of Illinois, occurring on tall grasses that grow in clumps. It is known only from this state and Minnesota.

Illinois Records.—Males and females,

taken June 30 to September 18, are from Amboy, Beach, Des Plaines, Fox Lake, Oak Lawn, St. Anne, Summit, Volo, Waukegan, and Zion.

2. *Laevicéphalus minimus* (Osborn & Ball)

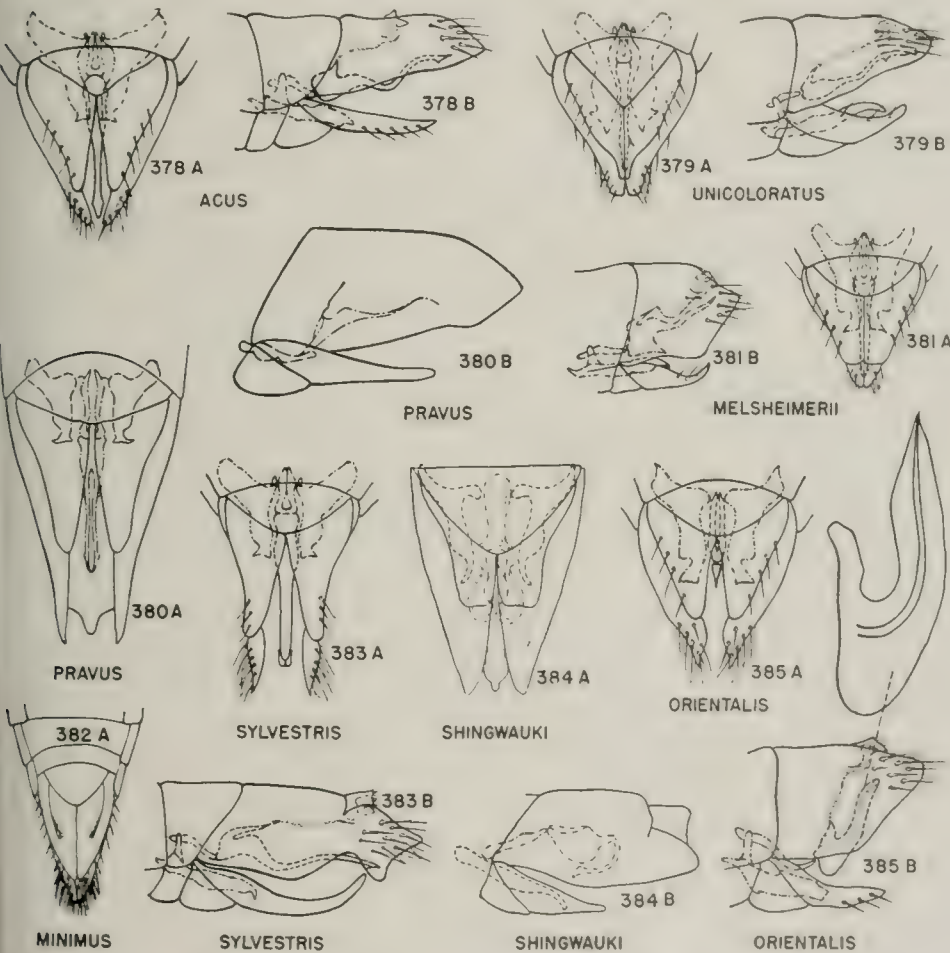
Deltocephalus minimus Osborn & Ball (1897, p. 211).

Length 2.5–3.0 mm. Small, greenish yellow, with a bluntly angled vertex. Paler on vertex, with traces of two brownish arcs on each side extending from apex toward ocellus. Elytra milky hyaline, nervures yellowish, faintly bordered with fuscous, especially in male. Face dull brownish. Female seventh sternite, fig. 386E, with posterior

margin roundedly produced, narrowly incised at middle, with a very small rounded notch on either side, median third black margined. Male plates, fig. 382A, tapering to bluntly pointed tips, almost as long as the pygofers and each bearing a black spot at middle.

This is a middle western species, and has been found on grasses of the genus *Stipa* in the *Sporobolus-Stipa* habitats of northern Illinois.

Illinois Records.—APPLE RIVER CANYON STATE PARK: July 11, 1934, Frison & DeLong, 7♂, 3♀; Aug. 22, 1935, DeLong & Ross, 2♂, 1♀. WARREN: Aug. 28, 1934, Frison & DeLong, 1♂, 5♀. WHITE PINES FOREST STATE PARK: Aug. 27, 1934, Frison & DeLong, 69♂, 69♀.



Figs. 378–385.—*Laevicéphalus*, male genitalia. A, ventral aspect; B, lateral aspect.

3. *Laevicephalus melsheimerii* (Fitch)

Amblycephalus melsheimerii Fitch (1851, p. 61).

Length 2.5–2.75 mm. Vertex longer than width between eyes, sharply angled. Female uniform yellowish, with milky white ner-

gus in lateral view, fig. 381B, broad at base, with a short dorsobasal process; notch at about the middle of caudal side producing a long narrowed attenuated process dorsal to notch.

Distributed through the eastern states and west to Colorado, this species occurs on dry uplands, pastures, and meadows in the *Danthonia* association, where it has been collected from *Danthonia spicata* and *compressa*.

Illinois Records.—Males and females, taken March 28 to October 3, are from Anvil Rock, Dixon Springs, Dolson, Elizabethtown, Gibsonia, Grand Detour, High Knob, Monticello, Muncie, Norris City, Ozark, Palos Park, and Starved Rock State Park.

4. *Laevicephalus unicoloratus* (Gillette & Baker)

Deltocephalus unicoloratus Gillette & Baker (1895, p. 89).

Deltocephalus oculatus Osborn & Ball (1897, p. 212). Preoccupied.

Deltocephalus nominatus Sanders & DeLong (1920, p. 9). New name for *oculatus* O. & B.

Length 3.5 mm. Pale yellowish to greenish. Vertex a little longer than basal width between eyes. Ocelli, impressed line on vertex, and eyes dark; interocellar line from apex to ocelli pale brownish. Elytra subhyaline, nervures yellowish. Female seventh sternite, fig. 386G, with median third of posterior margin produced, dark margined, and scarcely trilobate. Male plates, fig. 379A, convex, narrowed to produced attenuated tips. Aedeagus, fig. 379B, long, narrowed, and slender on median third, broadened on apical third and bearing a ventral tooth about one-fourth the distance from apex.

This species is common on *Andropogon* in the east-central states and in Illinois in certain of the dark prairie and sand prairie habitats.

Illinois Records.—CAVE IN ROCK: Oct. 2, 1934, Frison & Ross, 1 ♀. DONGOLA: May 11, 1917, 1 ♀. EVERGREEN PARK: Aug. 23, 1934, DeLong & Ross, 31 ♂, 28 ♀; July 1, 1935, DeLong & Ross, 5 ♂, 6 ♀. HANOVER: June 29, 1935, DeLong & Ross, 1 ♀. OAK LAWN: in lamp globe, Aug. 23, 1934, 1 ♂, 1 ♀. ST. ANNE: July 20, 1934, DeLong & Ross, 3 ♂, 16 ♀; Aug. 21, 1934, DeLong & Ross, 3 ♀; Aug. 26, 1935, DeLong & Ross, 1 ♀. VIENNA: June 14, 1934, DeLong &

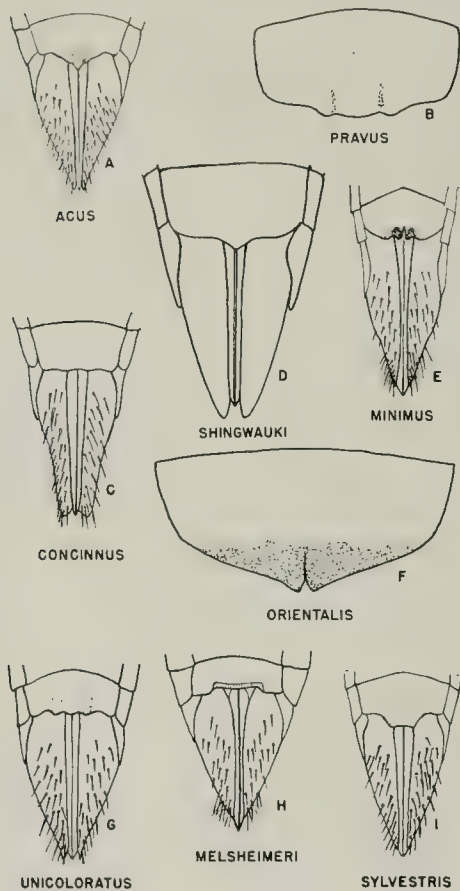


Fig. 386.—*Laevicephalus*. A–I, female genitalia.

vures. Male head, pronotum, and scutellum brighter yellow, a faint brown arc on either side of vertex extending from apex to black ocelli. Elytral nervures faintly bordered throughout with fuscous. Face pale brown.

Female seventh sternite, fig. 386H, with median half of posterior margin having a simple very shallow black-bordered excavation. Male plates, fig. 381A, broad at bases, only slightly narrowed to broadly rounded upturned tips appearing from below as almost truncate; a median brownish line expanding toward tip of each plate. Aede-

Ross, 1 ♀. ZION: July 16, 1935, DeLong & Ross, 1 ♂, 3 ♀; Aug. 7, 1935, DeLong & Ross, 1 ♀.

5. *Laevicephalus sylvestris* (Osborn & Ball)

Deltocephalus sylvestris Osborn & Ball (1897, p. 213).

Length 3.5 mm. Dull greenish, tinged with yellow. Vertex distinctly angled, about one-fourth longer than width between eyes. Ocelli and eyes dark; a rather heavy fuscous stripe on either side of apex extending obliquely onto disc, then broadening and continuing to pronotum. Elytra whitish or dull hyaline, nervures greenish yellow, often broadly margined with fuscous, especially on apical portions and along sutural line.

Female seventh sternite, fig. 386I, emarginate posteriorly on either side of an abruptly produced black truncated process that is almost one-third the length of the segment on the median third. Male plates, fig. 383A, with sides concavely narrowed to bluntly pointed divergent tips. Aedeagus long, in lateral view, fig. 383B, with basal third broadened and bearing a dorsal spine; apical two-thirds narrow and slightly enlarged at apex.

This distinctive species occurs with *mel-sheimerii* in the *Danthonia spicata* association and probably feeds on several of the grasses. It is a common and widely distributed species from the Great Lakes region to the Gulf Coast.

Illinois Records.—Many males and females, taken May 18 to November 4, are from Alton, Apple River Canyon State Park, Atlas, Barry, Cave in Rock, Dixon Springs, Dolson, Dubois, Eichorn, Fairfield, Fox Lake, Galena, Geff, Havana, Herod, Hope-dale, Jonesboro, Karnak, Mahomet, Marshall, Monticello, Mount Carmel, Muncie, New Milford, Newton, Olive Branch, Oregon, Ozark, Pike, Port Byron, St. Anne, Savanna, Seymour, Shawneetown, Temple Hill, Urbana, Vienna, Watson, White Pines Forest State Park, and Wilmington.

6. *Laevicephalus acus* (Sanders & DeLong)

Deltocephalus acus Sanders & DeLong (1920, p. 10).

Length 4 mm. Yellowish green, sharp headed. Vertex one-fifth longer at middle

than width between eyes; the median impressed line, ocelli, and arcuate line from apex toward eye pale brown. Elytra milky hyaline, veins paler, faintly bordered with fuscous. Face sordid yellow, with paler arcs.

Female seventh sternite, fig. 386A, with median half of posterior margin produced, forming a broad, pointed tooth with sinuate sides and margined with brown. Male plates, fig. 378A, concavely narrowed to bluntly pointed apices. Aedeagus in lateral view, fig. 378B, broad at base, with a very blunt dorsal spur; narrowed at one-third its length to a narrow apical portion that is slightly enlarged at apex.

This is a grass-feeding species that seems to be found more abundantly upon coarse grasses in swampy areas than elsewhere. It has not been taken on the prairies. It is northern in distribution, ranging from New York west to Wisconsin and Illinois.

Illinois Record.—WAUCONDA: July 23, 1934, DeLong & Ross, 1 ♀.

7. *Laevicephalus concinnus* (Sanders & DeLong)

Deltocephalus concinnus Sanders & DeLong (1917, p. 86).

Length 3 mm. Greenish, marked with longitudinal stripes. Vertex bluntly angled, as long as wide. Ocelli black; vertex, pronotum, and scutellum each with two broad parallel brownish stripes, and an additional stripe behind each eye on pronotum. Elytra with white nervures. Face dusky. Female seventh sternite, fig. 386C, slightly longer than preceding sternite, almost truncate, sinuate, and with median brown spot. The male is not known.

This species has been collected in tall grasses and sedges in marshes in Wisconsin and northern Illinois.

Illinois Records.—FOX LAKE: June 30, 1935, DeLong & Ross, 1 ♀; June 26, 1936, 4 ♀.

8. *Laevicephalus orientalis* DeLong & Davidson

Laevicephalus orientalis DeLong & Davidson (1935, p. 167).

Length 3.5–4.0 mm. Vertex as long as basal width between the eyes, creamy to bright yellow. Pronotum and scutellum greenish, washed with yellow. Elytra vary-

ing in color, sometimes dark green, with white or yellowish veins, often with apexes smoky.

Female seventh sternite, fig. 386F, without lateral angles, posterior margin produced, sloping to middle of segment, which is distinctly incised, leaving a pair of inconspicuous teeth at middle. Male plates, fig. 385A, broad at bases, strongly and convexly curved to rather blunt and broad apexes. Aedeagus in lateral view, fig. 385B, appearing broad, with a curved portion extending ventrally and posteriorly and produced by being curved upward; this structure open in the middle and appearing as two parallel pieces.

Distributed from Pennsylvania to Tennessee and Illinois, this species has been taken commonly in open woodland on *Elymus* grasses.

Illinois Records.—CAVE IN ROCK: May 7, 1932, H. L. Dozier, 1 ♀. DUBOIS: May 21, 1917, 1 ♂. EICHORN: Hicks Branch, June 13, 1934, DeLong & Ross, 6 ♀. ELIZABETHTOWN: May 27–31, 1932, Dozier, 1 ♀. HARDIN: June 5–9, 1932, Dozier, 1 ♀. MONTICELLO: June 11, 1934, Frison & DeLong, 1 ♂. SHAWNEETOWN: June 14, 1934, Ross & DeLong, 2 ♀.

9. *Laevicephalus pravus* DeLong

Laevicephalus pravus DeLong (1937b, p. 34).

Length 3.0–3.5 mm. Yellowish, resembling *unicoloratus* in general appearance. Vertex bluntly angled, a little wider between eyes than median length, bright yellow, unmarked. Ocelli and ovipositor black.

Female seventh sternite, fig. 386B, roundly produced, almost truncate. Male plates long, tapered to acute apexes. Aedeagus in lateral view, fig. 380B, narrowed at half its length and tapered to a long threadlike attenuated apex; in ventral view it appears broad at base, rapidly narrowed and produced, slightly enlarged just before apex, and with teeth on the outer margin; tip of aedeagus bluntly pointed.

This species was taken abundantly in a prairie habitat in northern Illinois, and from one other locality in the state. It is known only from Illinois.

Illinois Records.—DES PLAINES: Sept. 4, 1935, DeLong & Ross, 1 ♂; Sept. 18, 1935, DeLong & Ross, 15 ♂, 52 ♀. HANOVER: Aug. 22, 1936, 1 ♂.

59. *PSAMMOTETTIX* Haupt

Psammotettix Haupt (1929, p. 262).

Fig. 236B. Closely related to *Laevicephalus*, this genus is distinguished chiefly by having the male plates, figs. 387, 388, shorter than the valve, and the female seventh sternite, fig. 236, is usually broadly and concavely rounded and relatively simple on the posterior margin.

Twelve species have been recorded in this genus for the United States under the *striatus* group of *Laevicephalus* (DeLong & Knoll, 1945). Two species occur in Illinois.

KEY TO SPECIES

Male aedeagus, fig. 387, blunt and entire at apex; connective long, slender. . . . **1. striatus**
Male aedeagus, fig. 388, sharp pointed at apex and bifurcate one-third the length of aedeagus; connective short, horseshoe shaped. . . . **2. ferratus**

1. *Psammotettix striatus* (Linnaeus)

Cicada striata Linnaeus (1758, p. 437).

Length 3.5–4.0 mm. Greenish, markings variable in color. Vertex blunt and broadly angled, often with definite fuscous spots or blotches, interocellar line pale. Elytra variable, nervures frequently fuscous margined, and often so dark that elytra appear striped.

Female seventh sternite, fig. 236B, with posterior margin shallowly concave on median half. Male plates, fig. 387, short, apexes obliquely truncate and gently sloping to median line, the large round male valve almost obscuring the plates. Aedeagus connective twice as long as aedeagus, which is slender, curved dorsally, and bears a dorsally directed ventral process.

A transcontinental species, this is one of the most common of the grass leathoppers and is found in greater abundance in pastures and meadows than in prairie habitats.

Illinois Records.—Many males and females, taken May 14 to October 1, are from Algonquin, Alton, Amboy, Antioch, Arlington Heights, Barry, Beach, Bradley, Bushnell, Champaign, Decatur, Des Plaines, Effingham, Elizabeth, Evergreen Park, Forest City, Fox Lake, Fulton, Galena, Grafton, Grand Detour, Grays Lake, Hanover, Hardin, Havana, Homer, Ingleside, Kankakee, Macomb, Marshall, Mason City, McHenry, Monmouth, Monticello, Mount

Sterling, Muncie, New Holland, New Milford, Normal, Oak Lawn, Ogden, Oquawka, Orangeville, Palos Park, Pankeyville, Parker, Port Byron, St. Anne, Savanna, Seymour, Shawneetown, Sheffield, Springfield, Summit, Texas City, Urbana, Volo, Watson, Wauconda, Waukegan, White Heath, White Pines Forest State Park, and Zion.

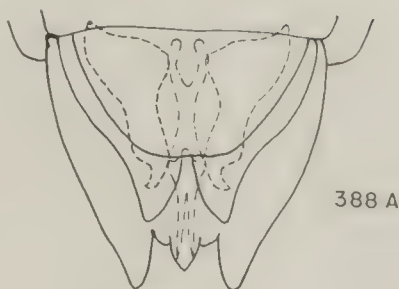
2. *Psammotettix ferratus* (DeLong & Davidson)

Laevicephalus ferratus DeLong & Davidson (1935, p. 170).

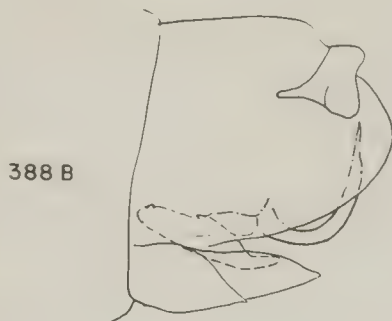
Length 3.5 mm. In size, form, and coloration this species resembles *striatus* so closely it cannot be separated by external markings or by external genital structures.

Female seventh sternite shallowly and concavely rounded as in *striatus*. Male plates, fig. 388, short and truncate. Connectives very short, in ventral view with a rounded horseshoe-shaped base; aedeagus short, angularly bent and directed upward, apex sharply pointed, appearing bifurcate in dorsal view.

This species occurs in various habitats and

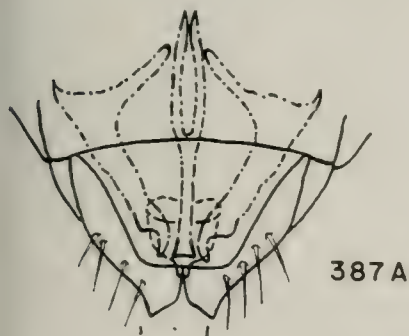


388 A

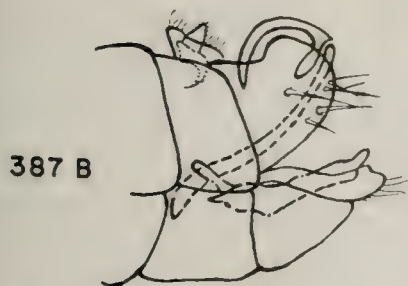


388 B

Fig. 388.—*Psammotettix ferratus*, male genitalia. A, ventral aspect; B, lateral aspect.



387 A



387 B

Fig. 387.—*Psammotettix striatus*, male genitalia. A, ventral aspect; B, lateral aspect.

has been taken along Lake Erie and in the Chicago area near Lake Michigan. It has also been recorded from Pennsylvania, but has been collected only in small numbers in these localities.

Illinois Records.—MACOMB: in pasture, July 3, 1934, DeLong & Ross, 1 ♂. ST. ANNE: July 20, 1934, DeLong & Ross, 1 ♂. VOLO: July 27, 1934, DeLong & Ross, 1 ♂, 2 ♀.

60. *AMPLICEPHALUS* DeLong

Amplicephalus DeLong (1926a, p. 83).

Fig. 208. Vertex transverse and broad, width between eyes greatly exceeding length at middle, strongly rounded or very broadly and bluntly angled with front. Elytra with central anteapical cell constricted and divided, and with one or two crossveins between first and second sectors. Form broad and robust.

KEY TO SPECIES

Tawny, with a row of four or six black spots just above margin of vertex. 1. *osborni*
Green, with a transverse black band just back of yellow vertex margin. 2. *estacadus*

1. *Amplipcephalus osborni* (Van Duzee)

Deltopcephalus osborni Van Duzee (1892c, p. 304).

Length 4.5–5.0 mm. Tawny yellow, with black markings. Vertex, fig. 389A, one-third broader than long, with four or six dark spots on anterior margin, the middle pair larger and prominent, the two next to each ocellus smaller, transverse, often wanting; in well-marked specimens there is usually a tawny interrupted transverse band between eyes, and an irregular spot at base on either side. Pronotum with traces of five pale longitudinal stripes. Elytral nervures white, often heavily margined with fuscous.

Female seventh sternite, fig. 389D, with posterior margin bisinuate, forming three

broadly rounded lobes, broadly margined with dark brown; lateral lobes prominent at sides. Male plates, fig. 389C, triangular, gradually narrowed to acute tips. Aedeagus in lateral view, fig. 389B, broad, apical portion inflated and narrowed to a bluntly pointed apex.

This is a fresh-water marsh species found especially in the northern states from Maine to Colorado.

Illinois Records.—Many males and females, taken May 8 to September 24, are from Amboy, Antioch, Beach, Clay City, Danville, Dubois, Fox Lake, Grand Detour, Havana, Oak Lawn, Oakwood, Port Byron, Princeton, Sun Lake, Volo, and Wauconda.

2. *Amplipcephalus estacadus* (Ball)

Athysanus estacadus Ball (1911, p. 200).

Length 3.5 mm. Yellow to greenish, with black bands. Vertex, fig. 389A, wider than median length, with a yellow margin, just back of and parallel to which is a broad black band. Pronotum with a transverse median light band. Elytral nervures light. Female seventh sternite, fig. 389D, short, posterior margin slightly and broadly emarginate. Male plates, fig. 389C, triangular, broad at base, convexly rounding to near middle, then concave, gradually narrowing to acute tips. Aedeagus broad in ventral view, fig. 389B, and deeply bifid at apex; in lateral view it appears notched on dorsal surface near base and is tapered to a pointed apex.

This is a grass-feeding species found abundantly in pastures and meadows. It is southern in distribution and will probably be found in southern Illinois.

61. *ARUNDANUS* DeLong

Arundanus DeLong (1935b, p. 180).

Fig. 220. The genus is characterized by having the vertex produced and bluntly angled, flat, margin rather thick but distinct, not rounded to front. Venation of wing with central anteapical cell greatly elongated, constricted, and divided by a crossvein at center; outer anteapical cell usually elongated but narrow; inner anteapical cell short and rather broad.

As far as known, the 14 described species of this genus are largely confined to cane, *Arundinaria tecta*, an abundant host along stream margins or in low moist areas in the

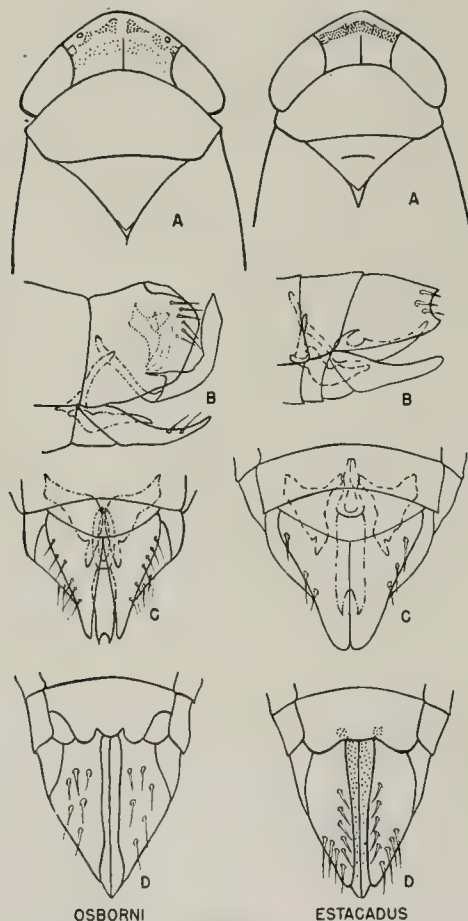


Fig. 389.—*Amplipcephalus*. A, head and pronotum; B, male genitalia, lateral aspect; C, male genitalia, ventral aspect; D, female genitalia.

southeastern United States. In Illinois the cane occurs north of the Ohio River, extending to some extent over the southern fourth of the state. Records of four species have been obtained in Illinois, and several other species may occur here.

KEY TO SPECIES

1. Yellow, orange, or brown, marked with black transverse lines or spots on margin of vertex.....2
Color white, yellow, orange, or some shade of brown, without black spots or lines on margin of vertex.....5
2. Vertex with a black wavy line on margin or just below; margin not white, bordered with dark lines.....3
Vertex margin white or pale, bordered with black lines above and below.....4
3. Vertex with a broad wavy line on margin, with four quadrate black spots above, fig. 390*A*.....1. **crumbi**
A heavy wavy line below vertex margin, an interrupted black band above, composed of three narrowly connected triangular spots on either side, fig. 390*B*.....2. **proprius**
4. Vertex with a broken line composed of four irregular triangular spots above margin, fig. 390*E*. Female seventh sternite, fig. 390*I*, deeply and roundedly excavated at middle. Male aedeagus, figs. 390*N*, 390*O*, terminating in sharply pointed processes.....3. **arundineus**
Vertex with a wavy line above the white margin, fig. 390*C*. Female seventh sternite, fig. 390*J*, appearing trilobate. Male aedeagus, figs. 390*P*, 390*Q*, rounded, blunt at apex, dorsal process broad, serrate on truncate tip.....4. **marginellus**
5. Dorsum uniform in color, deep orange in male, white in female.....5. **nacreosus**
Dorsum not uniform in color; vertex orange yellow, margin paler; elytra smoky yellow, nervures pale.....6. **flavotinctus**

1. *Arundanus crumbi* (DeLong)

Thamnottetix crumbi DeLong (1916, p. 81).

Length 5.0–5.5 mm. Orange yellow, with a rather broad wavy line on anterior margin of vertex, fig. 390*A*, and four quadrate spots just above black, the central pair larger; vertex one-fourth longer at middle than next to eyes. Elytra yellowish, nervures orange yellow, wings smoky. Female seventh sternite, fig. 390*K*, broadly and angularly excavated, lateral angles produced and prominent. Male plates elongate, longer than combined basal width, gradually tapered from bases to blunt apices. Aedeagus, figs. 390*R*, 390*S*, with a long tapering ventral process

that is curved dorsally and anteriorly at apex, also a broad dorsal process, blunt at apex, extending dorsally from base of aedeagus body and curved anteriorly.

Common on *Arundinaria tecta* in Tennessee, *crumbi* should occur in southern Illinois.

2. *Arundanus proprius* (DeLong)

Thamnottetix proprius DeLong (1918*b*, p. 238).

Length of male 4.5 mm. Resembling *shermani* Ball (1903, p. 230), in coloration but with a more strongly produced and angled vertex, fig. 390*B*. Vertex a little wider between eyes at base than median length; margin pale, bordered beneath by a uniform black band and above by a band composed of three large triangular spots on each side, the central pair of spots largest and decidedly separated. Male plates, fig. 390*M*, long and narrow, bluntly pointed. Aedeagus in lateral view, fig. 390*L*, curved dorsally at apex and enlarged into a half spearhead, the enlarged portion on the caudal margin. Style with a short outwardly curved apical process.

This species is known to occur in Tennessee only.

3. *Arundanus arundineus* (DeLong)

Thamnottetix arundineus DeLong (1926*b*, p. 91).

Length 4.5–5.0 mm. Smoky brown, tinged with orange. Vertex, fig. 390*E*, bluntly angled, almost one-fourth wider between eyes than length at middle; margin pale, bordered with brown below and with a broken brownish line above, the latter composed of four irregular triangular spots; two broad orange longitudinal bands arise near margin of vertex and extend across pronotum to basal angles of scutellum. Elytra smoky subhyaline, veins whitish.

Female seventh sternite, fig. 390*I*, produced on either side to form a pair of broadly rounded lobes, between which the posterior margin is broadly and roundedly excavated more than half way to the base. Male valve, fig. 390*O*, broad, triangular, plates long and narrow, almost three times as long as valve and gradually tapering to rather sharp apices. Ventral process of aedeagus, fig. 390*N*, with an enlarged blunt rounded apex; dorsal portion slightly enlarged at apex, truncate and with a serrate margin.

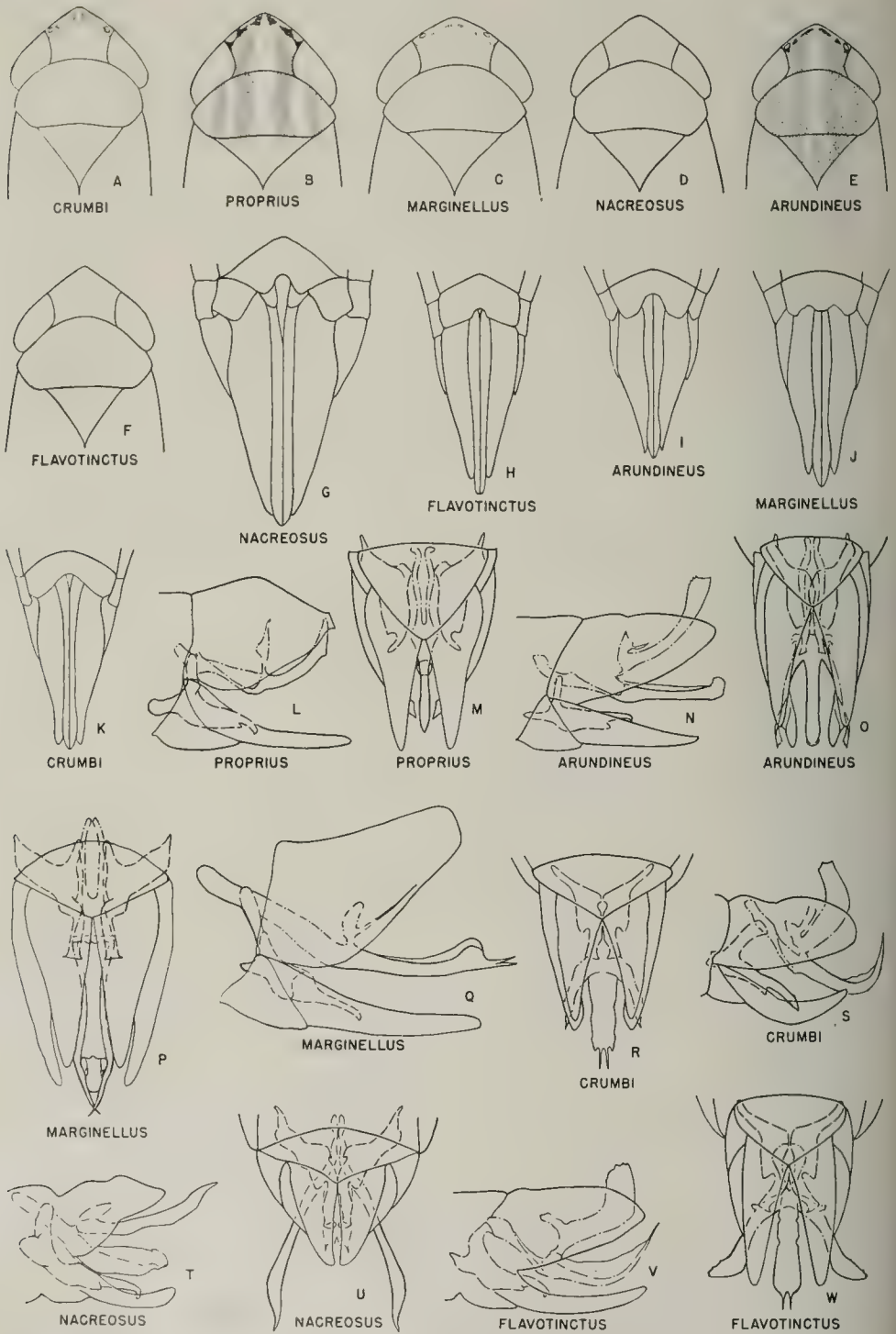


Fig. 390.—*Arundanus*. A-F, head and pronotum; G-K, female genitalia; L-W, male genitalia.

A common species on cane, *Arundinaria tecta*, *arundineus* occurs in southern Illinois and Tennessee.

Illinois Record.—VIENNA: June 14, 1934, DeLong & Ross, 12 ♂, 10 ♀.

4. *Arundanus marginellus* DeLong

Arundanus marginellus DeLong (1935*b*, p. 181).

Length 5.0–5.5 mm. Tawny to grayish, tinged with orange. Vertex, fig. 390*C*, flat, bluntly angled, a little more than half as long at middle as width between eyes; margin of vertex conspicuously white, bordered above by brownish wavy line and below by a fainter line. Pronotum marked with four conspicuous longitudinal orange stripes. Elytra with pale veins.

Female seventh sternite, fig. 390*J*, long, with prominent lateral angles, posterior margin indented on either side of a broad median rounded tooth, which is produced as far as the lateral angles and is bifid at apex. Male valve, fig. 390*P*, broad, obtusely angled; plates long, gradually tapering to narrow acute tips. Ventral portion of aedeagus, fig. 390*Q*, broad, elongate, slightly enlarged just before apex, then terminating in a pair of long spinelike structures; dorsal portion composed of a long slender tapered spine.

A common species on cane, *Arundinaria tecta*, *marginellus* occurs in Illinois and Tennessee.

Illinois Records.—HEROD: July 6–11, 1935, DeLong & Ross, 3 ♂, 1 ♀. KARNAK: Aug. 8, 1934, 1 ♀. THEBES: July 11, 1935, DeLong & Ross, 6 ♂, 13 ♀. VIENNA: savanna grasses, June 14, 1934, DeLong & Ross, 30 ♂, 16 ♀; July 10, 1935, DeLong & Ross, 4 ♂, 7 ♀.

5. *Arundanus nacreosus* (Crumb)

Chlorotettix nacreosus Crumb (1915, p. 196).

Length 5.0–5.5 mm. With distinct sexual dimorphic coloration. Male deep orange, female uniformly white. Vertex, fig. 390*D*, obtusely angulate, one-half longer at middle than next to eye. Female seventh sternite, fig. 390*G*, twice as broad as long, with posterior margin excavated half way to base by a broad triangular notch, which is interrupted on either side of middle by a pair of rounded lobes, presenting the appearance

of three distinct notches. Male valve, fig. 390*U*, convex anteriorly, rounded posteriorly, two and one-half times as broad as long; plates longer than broad, tips rounding. Aedeagus, fig. 390*T*, with a short broad blunt ventral portion and a pair of long slender bladelike structures comprising the dorsal portion.

Very abundant on cane, *Arundinaria tecta*, this species occurs in the Mississippi and Ohio river valleys in southern Illinois.

Illinois Records.—ELIZABETHTOWN: June 25, 1932, Ross, Dozier, & Park, 1 ♂. HEROD: Aug. 4, 1934, DeLong & Mohr, 1 ♀; June 24, 1936, DeLong & Ross, 5 ♂, 2 ♀. KARNAK: Aug. 8, 1934, DeLong & Mohr, 1 ♂, 1 ♀. VIENNA: June 14, 1934, DeLong & Ross, 54 ♂, 1 ♀; July 29, 1934, DeLong & Ross, 16 ♂, 21 ♀.

6. *Arundanus flavotinctus* (DeLong)

Thamnottix flavotinctus DeLong (1916, p. 82).

Length 5.5 mm. Yellowish, tinged with orange, margin paler than adjacent areas. Elytra smoky yellow, nervures pale. Vertex, fig. 390*F*, flat, a little wider between eyes at base than median length. Female seventh sternite, fig. 390*H*, with posterior margin broadly and angularly excavated half way to the base, bottom of excavation brownish. Male valve, fig. 390*W*, almost truncated, fitting in the concavity of the seventh sternite; plates rather short and broad, a spot near outer margin at base of each. Ventral portion of aedeagus, fig. 390*V*, long, gradually narrowed to acutely pointed upturned apex; dorsal portion broad, enlarged, and curved dorsally before blunt apex.

Common on cane, *Arundinaria tecta*, this species is found in the Mississippi River valley.

Illinois Record.—VIENNA: July 10, 1935, DeLong & Ross, 2 ♀.

62. *GRAMINELLA* DeLong

Graminella DeLong (1936*a*, p. 218).

Individuals of this genus usually have a produced and bluntly angled vertex with a thin margin, angled with front. Venation simple, central anteapical cell long and constricted at middle; outer anteapical cell comparatively short.

Individuals of the 14 known species of

the genus are comparatively small in size, 3.5–4.5 mm., and so far as is known are all grass feeders. They are common in the fresh- and salt-water marshes of the eastern United States, occurring especially upon the grasses of the *Spartina* association. Six species have been taken in Illinois; some of them occur on the wet and dry prairies.

KEY TO SPECIES

1. Vertex, pronotum, and scutellum with broad longitudinal red stripes, fig. 391C2 **1. aureovittata**
Without red longitudinal lines on vertex, pronotum, and scutellum 2
2. Vertex marked with four marginal spots 3
Vertex without black spots, sometimes with faint brownish markings 5
3. Row of black spots on vertex continuing through ocelli along anterior margins of eyes to antennae **2. nigrifrons**
Row of black spots not continuing below the vertex margin; ocelli often pale, inconspicuous 4
4. Length 4.5 mm. Spots on vertex large, conspicuous; female seventh sternite, fig. 391E3, with broad median sunken tooth; male plates, figs. 391E6, 391E7, one-half longer than combined basal width, apices pointed **3. fitchii**
Length not exceeding 4.0 mm. Paler in color; ocelli black, spots on vertex often faintly marked; female seventh sternite, fig. 391D3, concavely rounded, without tooth; male plates, fig. 391D6, as long as combined basal width **4. pallidula**
5. Female seventh sternite, fig. 391B3, with prominent sunken tooth; apical portion of male aedeagus, figs. 391B4, 391B5, concavely emarginate on ventral side before apex, and with a large black tooth on upper apical portion **5. mohri**
Female seventh sternite, fig. 391A3, concavely rounded, without tooth; male aedeagus, figs. 391A4, 391A5, concave on dorsal surface, a small black tooth on ventral median portion **6. ouaka**

1. *Graminella aureovittata* (Sanders & DeLong)

Thamnotettix aureovittatus Sanders & DeLong (1920, p. 16).

Length 4 mm. Yellowish or pale brown, ocelli black, a pair of small black triangular spots at apex of vertex; two broad bright red longitudinal bands extend across vertex, pronotum, and scutellum. Elytra brownish, with pale veins. Vertex, fig. 391C1, broadly rounded, one-fourth wider between eyes

than median length and only slightly produced before outer margins of eyes.

Female seventh sternite, fig. 391C3, rather deeply and roundedly excavated on median half of posterior margin, brown bordered; underlying sternite shows conspicuously at lateral edges of seventh sternite. Male plates, fig. 391C6, short and broad, rounded. Aedeagus, figs. 391C4, 391C5, in ventral view broadened at apex and narrowly notched; in lateral view tapered to a pointed apex. Style as in fig. 391C2.

This species occurs abundantly on the wet prairies in the Chicago area. It is recorded from Florida, Massachusetts, and Illinois.

Illinois Records.—OAK LAWN: in lamp globe, Aug. 22, 1934, 14 ♂, 10 ♀; Aug. 23, 1934, Frison & Ross, 1 ♂; sand prairie, Aug. 27, 1934, 1 ♀; Sept. 6, 1935, T. H. Frison, 1 ♂. ST. ANNE: July 20, 1934, DeLong & Ross, 1 ♀. SUMMIT: July 17, 1935, DeLong & Ross, 1 ♂, 3 ♀; Aug. 21, 1935, DeLong & Ross, 1 ♂, 1 ♀.

2. *Graminella nigrifrons* (Forbes)

Cicadula nigrifrons Forbes (1885, p. 67).
Thamnotettix perpunctata Van Duzee (1894b, pp. 200, 212).

Length 2.5–4.0 mm. Yellowish green, marked with black spots. Vertex bluntly angled, one-third wider between eyes than median length, with a row of black spots on anterior margin extending down on to front next to eyes. Face almost black and marked with irregular yellow spots. Elytra with pale nervures, these often bordered with fuscous.

Female seventh sternite emarginate posteriorly. Male plates short, broad at base, and narrowed to acute apices. Aedeagus rather rapidly narrowed on basal third to a long slender dorsally curved apical portion, the apex of which is blunt and bent anteriorly.

This is one of the most abundant and common of the grass-feeding species of leafhoppers in the eastern half of the United States. It can be found upon almost every lawn, pasture, and meadow and upon almost every cultivated crop.

Illinois Records.—Many males and females, taken May 11 to November 13, are from Albion, Algonquin, Alton, Anvil Rock,

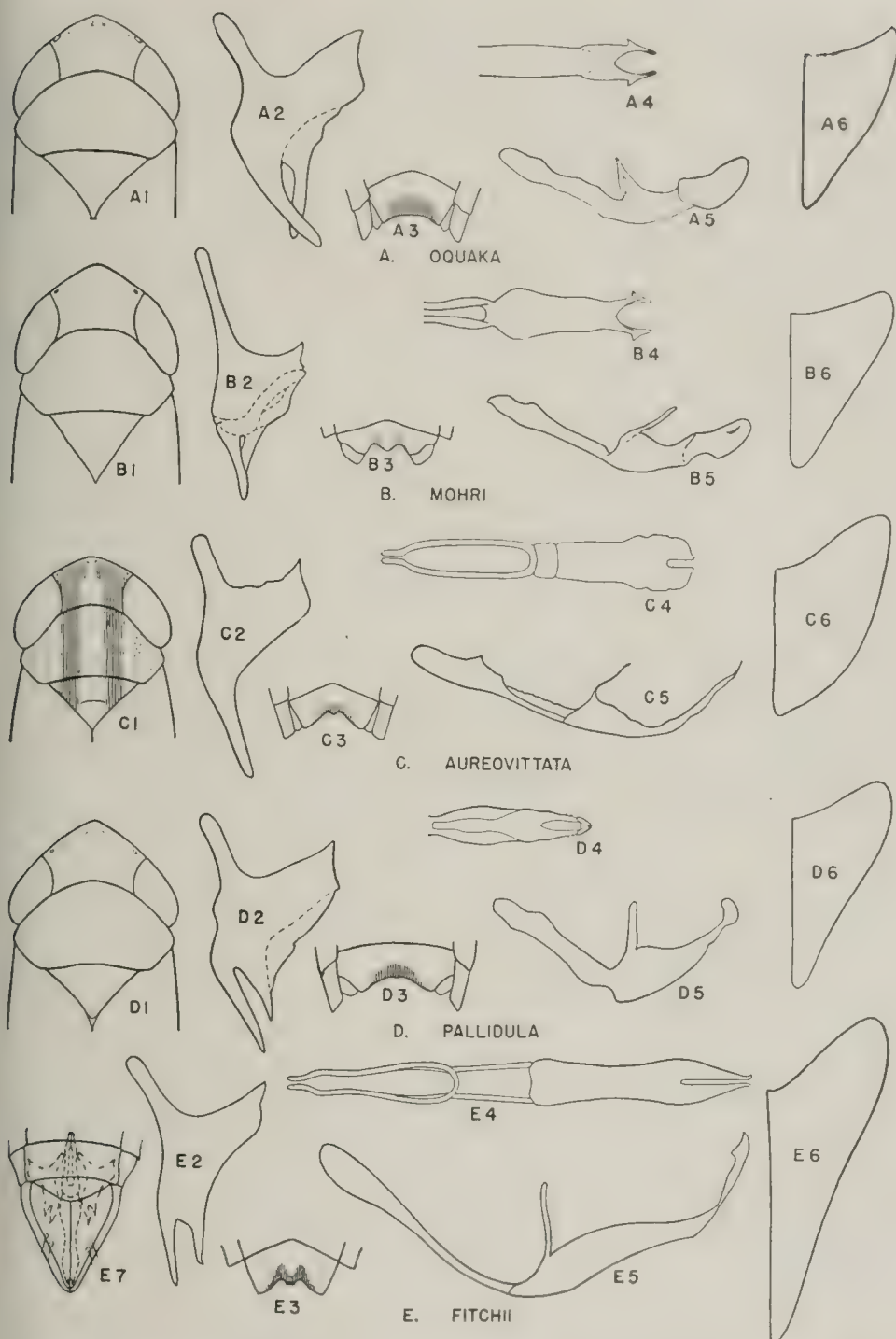


Fig. 391.—*Graminella*. 1, head and pronotum; 2, style; 3, female seventh sternite; 4, ventral view of aedeagus; 5, lateral view of aedeagus; 6, male plate; 7, ventral view of male genitalia.

Anna, Apple River Canyon State Park, Barry, Bushnell, Cache, Cairo, Carbondale, Cave in Rock, Champaign, Cobden, Collinsville, Danville, Decatur, Detroit, Dixon Springs, Dolson, Dongola, Du Quoin, East Cape Girardeau, Eichorn, Elizabethtown, Evergreen Park, Fulton, Geff, Giant City, Gibsonia, Golconda, Grafton, Gulfport, Harrisburg, Havana, Herod, High Knob, Hillsboro, Horseshoe Lake, Kampsville, Kankakee, Karnak, Lawrenceville, Lincoln, Luther, Marshall, McHenry, Meredosia, Metropolis, Mokena, Momence, Mount Carmel, Muncie, Norris City, Oak Lawn, Oakwood, Ogden, Olive Branch, Oquawka, Pike, Port Byron, Princeton, Pulaski, Putnam, Quincy, St. Anne, St. Joseph, Seymour, Shawneetown, Sparta, Sugar Grove, Temple Hill, Thomson, Urbana, Ursa, Vandalia, Vienna, Villa Ridge, Volo, Warsaw, Watson, West Union, White Pines Forest State Park, Wolf Lake, and Zion.

3. *Graminella fitchii* (Van Duzee)

Thamnotettix fitchii Van Duzee (1890a, p. 133).

Length 4.5 mm. Yellowish green, with four black spots above margin of vertex, a round one next to each ocellus and a pair of triangular spots just back of apex; vertex bluntly angled, slightly wider between eyes than median length. Elytra with pale veins.

Female seventh sternite, fig. 391E3, roundedly excavated on either side of a median slightly produced broad sunken tooth; black markings of posterior margin causing it to appear more deeply notched. Male plates, figs. 391E6, 391E7, long, gradually and concavely tapered to bluntly pointed apices; valve with a pair of processes at apex. Aedeagus in ventral view, fig. 391E4, broad, slightly constricted at middle, enlarged on apical third, then tapered to a pair of laterally directed pointed apical processes that are formed by a deep narrow median incision; in lateral view, aedeagus, fig. 391E5, broad at base, narrowed near apex, then apparently enlarged by the curling of the apex. Style as in fig. 391E2.

This is the most common species of the genus and has been found throughout Illinois. Distributed through the eastern states and west to Kansas, it occurs in abundance in fresh-water marshes and swamps, on

rank growths of grasses, and on the moist prairies.

Illinois Records.—Many males and females, taken May 20 to October 5, are from Algonquin, Alton, Antioch, Apple River Canyon State Park, Beach, Detroit, Dixon Springs, Dolson, Dongola, Elgin, Fern Cliff, Fountain Bluff, Fox Lake, Fulton, Geff, Grafton, Grand Detour, Gulfport, Hamilton, Hanover, Havana, Herod, Homer, Karnak, Keithsburg, Momence, Monticello, Muncie, Newton, Norris, Oak Lawn, Olive Branch, Oquawka, Princeton, Putnam, Quincy, Rock Island, Sheffield, Spring Valley, Starved Rock State Park, Sugar Grove, Summit, Sumner, Temple Hill, Urbana, Vienna, Volo, Waltersburg, White Heath, Wilmington, and Zion.

4. *Graminella pallidula* (Osborn)

Thamnotettix pallidulus Osborn (1898, p. 245).

Length 4 mm. Pale yellow, with six black spots on or above margin of vertex, middle pair sometimes obsolete, the outer pair on margin anterior to eyes. Vertex, fig. 391D1, bluntly and roundedly angled, one and one-half times as wide between eyes at base as length at middle. Elytra pale brown or tawny, nervures paler.

Female seventh sternite, fig. 391D3, with posterior margin broadly and deeply excavated, bearing an obtuse tooth at its apex. Male plates, fig. 391D6, convexly narrowed to acute apices. Styles, fig. 391D2, broad, with two anterior processes, which are directed outwardly. Aedeagus in ventral view, fig. 391D4, tapered to bluntly rounded apex; in lateral view, fig. 391D5, broad at base, tapered to a very narrow neck just before a rounded bulbous apex.

This species occurs on prairie grasses and is known only from Illinois and Iowa.

Illinois Records.—EVERGREEN PARK: Aug. 23, 1934, DeLong & Ross, 1♀. HAVANA: Aug. 8, 1934, Frison & Mohr, 1♀.

5. *Graminella mohri* DeLong

Graminella mohri DeLong (1937c, p. 50).

Length 4 mm. Yellowish, unmarked. Vertex, fig. 391B1, bluntly angled, about one-third wider between eyes than length at middle. Female seventh sternite, fig. 391B3, shallowly, roundedly excavated on

either side of a broad rounded median tooth; central half of segment brownish. Male plates, fig. 391B6, short and broad, gradually narrowed to blunt apices. Styles, fig. 391B2, rather narrow, each with a long basal process. Aedeagus in ventral view, fig. 391B4, broad at base, slightly tapered to apical third, then enlarged; apex bearing a broad deep V-shaped notch, on either side of which is a blunt pointed apical process that is abruptly set off from body of aedeagus at base; in lateral view, the apical portion of aedeagus, fig. 391B5, constricted at base on ventral side, then enlarged; apex broadly rounded, a large black spine on anterior apical margin.

This is a common species of the sand prairies and is common along the Great Lakes and in the upper Mississippi River valley. It is recorded from Pennsylvania, Illinois, and Kansas.

Illinois Records.—Many males and females, taken June 26 to August 22, are from Alton, Beach, Fulton, Hanover, Mahomet, Thomson, Waukegan, and Zion.

6. *Graminella oquaka* DeLong

Graminella oquaka DeLong (1937c, p. 51).

Length 4 mm. Pale yellow, with black ocelli and indications of four very pale spots on margin of vertex; vertex, fig. 391A1, bluntly angled, about one-third wider between eyes than length at middle.

Female seventh sternite, fig. 391A3, with central half of posterior margin broadly and roundedly excavated about one-fourth the distance to base, at the apex of which is a slightly produced broad median tooth. Male plates, fig. 391A6, rather short, broad at bases, gradually narrowed to acute apices. Each style, fig. 391A2, broad, the apical process long, curved outwardly. Aedeagus in ventral view, fig. 391A4, rather broad, slightly broader on apical third; apex broadly, deeply excavated by a U-shaped notch forming two narrow pointed apical processes that are broadened toward base and abruptly set off from body of aedeagus; in lateral view, fig. 391A5, the apical third is broadened, rounded on ventral surface; apex bluntly rounded, a black tooth on median ventral portion.

Known only from Illinois, this species occurs on bunch grass on the sand prairies of the upper Mississippi River valley.

Illinois Records.—HANOVER: Aug. 22, 1935, DeLong & Ross, 1♂. OQUAWKA: July 3, 1934, DeLong & Ross, 8♂, 7♀. THOMSON: June 30, 1935, DeLong & Ross, 3♂, 1♀. ZION: July 25, 1934, Frison & DeLong, 6♀.

63. *AMBLYSELLUS* Slesman

Amblysellus Slesman (1930, p. 131).

Vertex produced, almost right angled, wider between eyes than length at middle. Front broad at apex, triangular, clypeus long. Elytra short and broad. Pronotum with a shiny band on front half.

Only one species has been placed in this genus.

1. *Amblysellus curtisii* (Fitch)

Amblycephalus curtisii Fitch (1851, p. 61).

Jassus nervatus Provancher (1872, p. 378).

Length 3.5 mm. Small, greenish yellow, with black markings. Vertex, fig. 397A, sharply angled, as long as width between eyes; a pair of small black spots on apex, a pair of large shiny black spots between these and a little in front of eyes. Anterior portion of pronotum produced between the eyes, shiny black, posterior portion greenish yellow, narrowly margined with fuscous posteriorly. Elytra brown, the margins and nervures greenish yellow.

Female seventh sternite, fig. 397B, with lateral margins arising near base and produced to posterior margin, which is slightly excavated on either side of a short rounded median lobe; lobes of underlying membrane visible at either side. Male plates, fig. 398A, as long as combined basal width, gradually narrowed to acutely pointed apices. Aedeagus as in fig. 398B.

This is a common species in bluegrass meadows and pastures, also on small grains and legumes in Illinois. It occurs in the northeastern states, Tennessee, and in many parts of the Middle West.

Illinois Records.—Many males and females, taken June 2 to November 29, are from Algonquin, Antioch, Apple River Canyon State Park, Bloomington, Carbondale, Champaign, Dolson, Fox Lake, Galena, Ingleside, Kankakee, New Milford, Oakwood, Pecatonica, Rock Island, Rockton, Urbana, White Heath, White Pines Forest State Park, and Wilmington.

64. *UNOKA* Lawson

Unoka Lawson (1928, p. 456).

Fig. 225. Related to *Driotura*, but with vertex more angularly produced, almost as long as basal width, and with sloping vertex more broadly rounded to front. The pronotum is slightly longer than vertex. The brachypterous elytra extend to the pygofer, and the macropterous wings extend beyond the tip of the abdomen, forming three ante-apical cells, which are distinct in both forms of elytra; apical cells absent in brachypterous form.

Only one species, *ornata*, is known in this genus, and it has not been recorded for Illinois. However, several species of leafhoppers with western distribution similar to *ornata* have been taken on the sand prairies in Illinois along the Mississippi River, and it may be collected at some future time in the western portion of the state.

1. *Unoka ornata* (Gillette)

Athysanus ornatus Gillette (1898a, p. 29).

Length 2-3 mm. Vertex bluntly angled, wider between eyes than median length, and broadly rounded with front. Pronotum two and one-half times as wide as long and slightly longer than vertex. Elytra reaching to pygofer in brachypterous form and produced beyond abdomen in macropterous form. Face, vertex, pronotum, and scutellum black. Posterior two-thirds of pronotum and apex of scutellum yellow. Elytra milky white, with three black transverse bands: a narrow basal one, a wider median one, and a wide apical one; in brachypterous specimens the apical black band covers the apex of the elytra; in macropterous specimens, fig. 225, there is white coloration beyond the apical black band.

Female seventh sternite with posterior border broadly emarginate, emargination with two small rounded median teeth. Male valve long, angled at apex; plates elongate, triangular, exceeding pygofer, slightly and concavely rounded to acute tips.

This species occurs in Kansas and Nebraska on short grasses.

65. *UNERUS* DeLong

Unerus DeLong (1936a, p. 219).

Closely related to *Deltocephalus*. The general appearance is deltocephaloid but it

differs from the species of *Deltocephalus* by having only one crossvein between the two sectors instead of two crossveins. The vertex is bluntly angled and rounded to front, without a prominent margin. The genitalia are similar to those of *Deltocephalus*. A single species, *colonus*, is recognized for this genus.

1. *Unerus colonus* (Uhler)

Deltocephalus colonus Uhler (1895, p. 80).

Deltocephalus comatus Ball (1900c, p. 343).

Athysanus villicus Crumb (1915, p. 194).

Length 2.5-3.0 mm. Yellowish, with two large round black spots on anterior margin of the vertex and two dark points at apex. Vertex as long as basal width. Front yellow, tinged with orange. Pronotum yellow; a transverse band on the anterior margin and a broad one on the posterior margin orange. Elytra yellowish hyaline. Abdomen orange above, venter pale. Female seventh sternite emarginate posteriorly, emargination with a small median tooth. Male plates gradually narrowed to acute tips.

This is a common meadow and pasture species in the eastern United States.

Illinois Records.—CAVE IN ROCK: Oct. 2, 1934, Frison & Ross, 6♂, 7♀; July 9, 1935, Ross & DeLong, 1♂, 1♀. DIXON SPRINGS: July 29, 1934, DeLong & Mohr, 1♀. EICHORN: June 13, 1934, DeLong & Ross, 2♀. GOLCONDA: Sept. 4, 1924, T. H. Frison, 1♀. VIENNA: on grass, June 14, 1934, DeLong & Ross, 4♂, 1♀; Aug. 3, 1934, DeLong & Mohr, 14♂, 4♀.

66. *GILLETTIELLA* Osborn

Gillettiella Osborn (1930, p. 689).

Figs. 210, 233A. This genus is characterized by a head that appears conical; elytra short, and ovipositor long in the female.

Three species are at present placed in this genus, none of which has been collected in or recorded for Illinois. However, since they occur in states just west of Illinois, at least one species may be found in the short grass areas of the state.

1. *Gillettiella atropuncta* (Gillette)

Deltocephalus atropunctus Gillette (1898a, p. 28).

Length of male 2 mm.; female 4 mm. Small, with a produced vertex that bears

a black spot at apex. Vertex sharply produced, margins rounded to front, about twice as long at middle as basal width between eyes. Color dull gray, with a black spot at apex of vertex. Pronotum with a transverse row of dark spots anteriorly.

Female seventh sternite with the posterior margin rounded to small lateral processes, margin slightly excavated between lateral processes on either side of a broad rounded middle portion, which is produced the length of lateral processes. Male pygofers with apexes broadly rounded. Valve as long as preceding segment, apex sharply angled. Plates broad at bases, inner margins contiguous, outer margins rounded to sharp apices medially. Each style narrowed on outer third; aedeagus long and slender, in lateral view bent dorsally into a semicircle.

This species has been recorded from Kansas, Nebraska, Colorado, and Texas.

67. *STIRELLUS* Osborn & Ball

Stirellus Osborn & Ball (1902, p. 250).

Vertex conically produced, narrow, longer at middle than width between eyes, disc convex, sloping, and merging with front. Elytra short and broad, venation simple. Ovipositor exceeding pygofers.

Thomas (1933) and subsequent authors recorded seven species and two varieties of *Stirellus* for the United States, and two of these occur in Illinois.

KEY TO SPECIES

Vertex, fig. 395*A*, greenish, with apex broadly black; elytra greenish yellow, striped with black. **1. bicolor**
Vertex, fig. 396*A*, brown, with four spots arranged in two pairs, one pair posterior to the others, the anterior pair larger and sometimes confluent; elytra brownish, not striped. **2. obtutus**

1. *Stirellus bicolor* (Van Duzee)

Athysanus bicolor Van Duzee (1892*b*, p. 114).
Deltoccephalus virgulatus Uhler (1895, p. 78).

Length 3.0–3.5 mm. Small, color quite variable, usually greenish yellow, marked with black. Vertex, fig. 395*A*, acutely and conically pointed, as long at middle as width between eyes. Vertex with a pair of black spots before middle, often confluent and covering anterior half. Pronotum with a dark band on anterior portion, often extending across base of elytra. Elytra each with

claval suture, margins of suture, and apical margin dark fuscous, in male often entirely fuscous; nervures indistinct. Female seventh sternite, fig. 395*B*, with posterior margin broadly and shallowly concave. Male plates, fig. 400, short, narrowed to broad blunt apexes, which are about half as wide as bases.

This is a common meadow species throughout the state and is frequently found upon clover, alfalfa, and other crops. It is widely distributed in the eastern and middle western parts of the United States.

Illinois Records.—Many males and females, taken June 14 to October 2, are from Albion, Alton, Alto Pass, Anna, Brownfield, Carbondale, Cave in Rock, Cobden, Dixon Springs, Dongola, Dubois, Elizabethtown, Fern Cliff, Fountain Bluff, Gibsonia, Grafton, Grand Tower, Harrisburg, Havana, Herod, Jonesboro, Karnak, Luther, Makanda, Marshall, Metropolis, Oakwood, Odin, Shawneetown, Temple Hill, Thebes, Urbana, Vienna, and Wolf Lake.

2. *Stirellus obtutus* (Van Duzee)

Athysanus obtutus Van Duzee (1892*b*, p. 115).

Length 3.0–3.5 mm. Brownish, with four spots on disc of vertex. Vertex, fig. 396*A*, as long at middle as basal width between eyes, with four spots between eyes, the anterior pair darker and usually larger than the posterior pair. Pronotum with a row of brownish spots on anterior margin often confluent. Elytra brownish subhyaline, nervures pale. Female seventh sternite, fig. 396*B*, with posterior margin broadly, shallowly excavated. Male plates, fig. 399, convexly rounded to broad blunt apexes, which are about half as wide as basal width.

Although southern in distribution, this is a common species upon grasses in most parts of Illinois. It is abundant in meadows and pastures and upon cultivated crops of many types.

Illinois Records.—Many males and females, taken April 16 to December 4, are from Anvil Rock, Carbondale, Carmi, Cave in Rock, Centralia, Clay City, Cobden, Dixon Springs, Dolson, Dongola, Dubois, East Cape Girardeau, Elizabeth, Fern Cliff, Gibsonia, Golconda, Hardin, Heathsville, Herod, Karbers Ridge, Marshall, Mounds, Murphysboro, Norris City, St. Anne, Shawneetown, Urbana, Vienna, Watson, and Wolf Lake.

Fig. 392.—*Commellus comma*.68. *COMMELLUS* Osborn & Ball

Commellus Osborn & Ball (1902, p. 245).

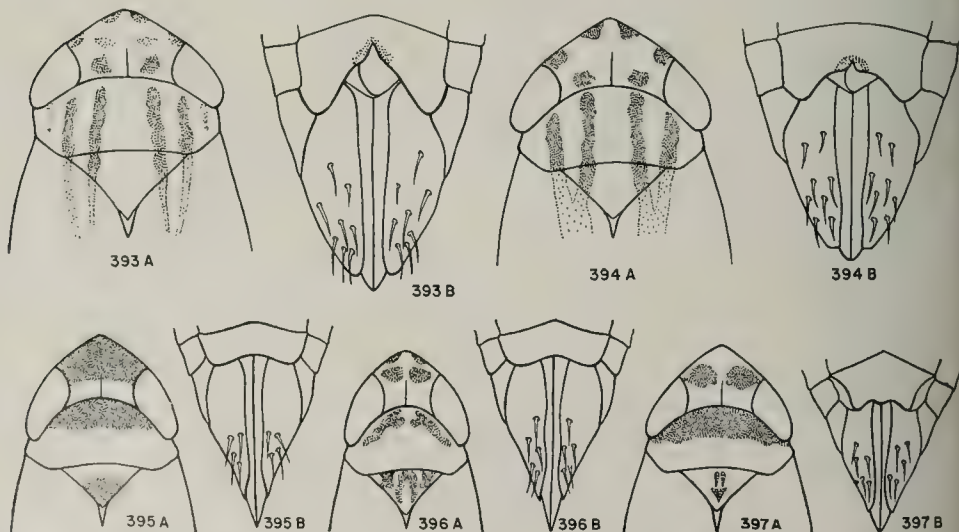
Fig. 392. Form broad and stout. Vertex flattened above, produced in front of eyes, acutely angled with front. Elytra of two forms shorter or decidedly longer than abdomen. Second cross nervure often present.

Four species have been placed in this

genus, and all are prairie forms. Two of them have been found in Illinois.

KEY TO SPECIES

Elytra marked with four distinct, separate stripes; two stripes on pronotum, fig. 394*A*, fused to form stripe on clavus . . . 1. *comma*
Elytra marked with eight distinct and separate stripes; two stripes on pronotum, fig. 393*A*, forming two separate narrower stripes on clavus . . . 2. *colon*

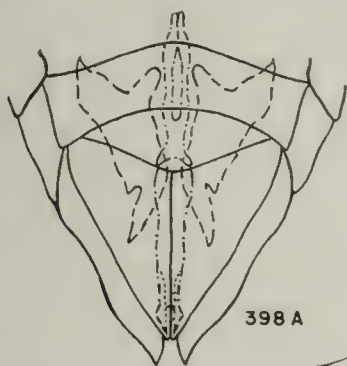


A, head and pronotum; *B*, female genitalia.

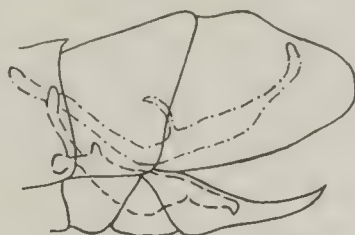
Fig. 393.—*Commellus colon*.Fig. 394.—*Commellus comma*.Fig. 395.—*Stirellus bicolor*.Fig. 396.—*Stirellus obtutus*.Fig. 397.—*Amblysellus curtisii*.

1. *Commellus comma* (Van Duzee)*Athysanus comma* Van Duzee (1892b, p. 114).

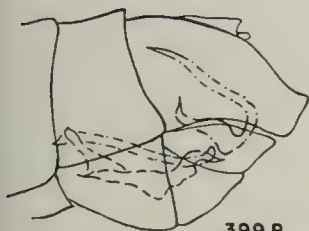
Fig. 392. Length 4.5–5.0 mm. Broad, stout, creamy white, marked with brown.

Vertex, fig. 394*A*, obtusely angulate, two-thirds as long as basal width between eyes; four black spots on anterior margin extending onto face; a pair of black spots at base of vertex. Pronotum and scutellum with

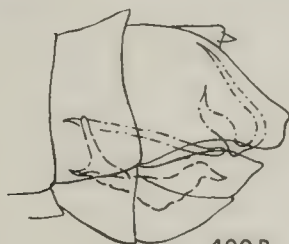
398 A



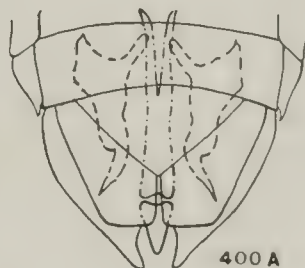
398 B



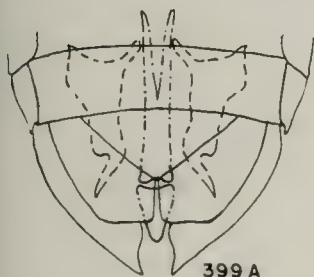
399 B



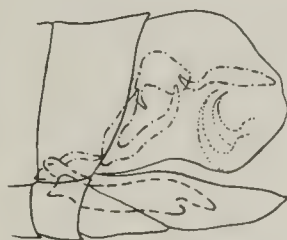
400 B



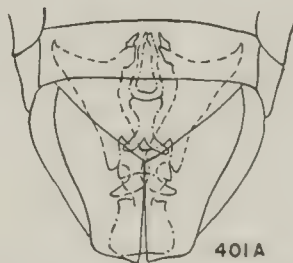
400 A



399 A



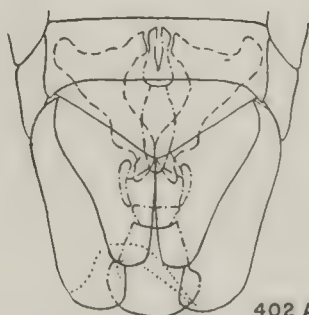
401 B



401 A



402 B



402 A

Male genitalia. A, ventral aspect; B, lateral aspect.

Fig. 398.—*Amblysellus curtisii*.Fig. 400.—*Stirellus bicolor*.Fig. 399.—*Stirellus obtutus*.Fig. 401.—*Commellus comma*.Fig. 402.—*Commellus colon*.

four parallel longitudinal stripes. Elytra creamy white, the two bands from pronotum coalescing and extending across each clavus; a broad brown band on claval suture and a narrower band on inner branch of first sector. Female seventh sternite, fig. 394B, with prominent posterior angles, between which the posterior margin is deeply, concavely excavated with a shallow black-margined incision at apex. Male plates, fig. 401, narrowed at apex to about half their basal width; apexes broad and blunt.

This is a middle western and northeastern species, and in Illinois occurs in the same association as *Dorycephalus platyrhynchus*. It is reported by Osborn & Ball (1897) as occurring on *Elymus canadensis*, but has not been definitely associated with this species of plant in Illinois.

Illinois Records.—DECATUR: June 29, 1935, Frison & Mohr, 19♂, 14♀. GALENA: July 10, 1934, DeLong & Ross, 2♀. LILLY: June 11, 1914, 1♀. ST. JOSEPH: June 27, 1915, 1♀. WESTERN SPRINGS: Aug. 16, 1936, 1♀. ZION: July 25, 1934, H. H. Ross, 1♀.

2. *Commellus colon* (Osborn & Ball)

Athysanus colon Osborn & Ball (1897, p. 223).

Length 4.5–5.0 mm. Pale, resembling *comma* but with more dark stripes on the elytra. Vertex, fig. 393A, two-thirds as long as width between eyes. Vertex, pronotum, and scutellum with spots and stripes as in *comma*. Each elytron with eight brownish stripes as follows: three on clavus, two of which are continuous with stripes on pronotum and scutellum, one on commissural line, and four on disc of elytron.

Female seventh sternite, fig. 393B, with posterior margin deeply and angularly excavated, black margined at apex. Male plates, fig. 402, short, broad, narrowed to about half their basal width at apices, which are broadly rounded.

This is a distinctly marked species, and the eight stripes on the elytra and the characters of the internal male genitalia serve to separate it from *comma*. A prairie species that occurs on *Stipa spartea*, *colon* is known to occur only in the states of Iowa, Minnesota, and Illinois.

Illinois Records.—ELGIN: prairie hill, Aug. 10, 1945, Ross & Sanderson, 12♂, 7♀; Aug. 1, 1944, Ross & Sommerman, 2♀.

69. *DORATURA* Sahlberg

Doratura Sahlberg (1871, p. 291).

Fig. 240. The vertex is rounded, shorter at middle than width between eyes. The anterior margin of vertex is rather sharply angled, slightly overhanging the front; slightly depressed just behind the middle of disc of vertex. The ovipositor is long and slender.

One species of this genus is known to have been imported from Europe and is well established in Wisconsin.

1. *Doratura stylata* (Boheman)

Athysanus stylatus Boheman (1847, p. 31).

Length 3.5–4.0 mm. Gray to brownish, with three conspicuous black spots on anterior margin of vertex. Vertex broadly rounded, produced at middle, more than half as long at middle as basal width between the eyes, longer than pronotum. Elytra short, leaving most of abdomen exposed. Dorsal portion of abdominal segments with a series of spots or dots that usually form longitudinal rows. Face pale, marked with two rather broad conspicuous transverse black bands. Female seventh sternite broad, with posterior margin truncate, not produced. Ovipositor long, slender, decidedly longer than pygofer. Male plates short, rather broad, rounded.

This species has not been collected in Illinois.

70. *DRIOTURA* Osborn & Ball

Driotura Osborn & Ball (1898, p. 87).

Fig. 403. Head short, transverse, almost parallel margined, obtusely conical. Eyes large, face short and broad. Pronotum short, transversely striate posteriorly. Elytra coarsely rugose, short, extending either to second abdominal segment only or almost to end of abdomen.

The members of this genus are grass-feeding species and are found in pastures or prairie habitats. Three species and three varieties are known for the United States. Three of these have been taken in Illinois, and one other may occur here.

KEY TO SPECIES

1. Black, reddish brown, or in part tawny yellow.....2

- Gray, vertex and pronotum marked with white.....1. **robusta**
 2. Vertex and pronotum reddish brown.....
 3. **gammaroides** var. **fulva**
 Vertex and pronotum black.....3
 3. Shiny black, without definite pale markings.....2. **gammaroides**
 Black, with elytra and last two or three segments of abdomen tawny yellow.....
 4. **gammaroides** var. **flava**

1. *Driotura robusta* Osborn & Ball

Driotura robusta Osborn & Ball (1898, p. 87).

Length 2.75–3.5 mm. Small, robust, gray, with light bands on pronotum. Vertex short, transverse, almost parallel margined, twice as wide as long; a median longitudinal line, two spots on disc, a band between vertex and front, and a stripe on base with white lines extending forward from it along the eyes. Face with a black band near clypeus, pale above, with dark arcs. Pronotum with anterior third black, white posteriorly, often bordered with black on lateral margins. Elytra black, with nervures and ramose lines connecting them light. Light colored specimens almost white.

Female seventh sternite slightly emarginate posteriorly. Male plates with inner margins rounded, outer edges emarginate, apices obtuse, widely separated.

This species occurs on small grasses and is frequently found in certain meadow or prairie habitats. It is recorded from the Middle West, but is not yet known from Illinois.

2. *Driotura gammaroides* (Van Duzee)

Athysanus gammaroides Van Duzee (1894b, p. 209).

Fig. 403. Length 3–4 mm. Short, black, robust, with long or short elytra. Vertex bluntly conical, twice as wide as long; usually glossy black, often with scattered reddish-brown markings. Legs and spines often reddish brown. Female seventh sternite broadly and convexly rounded. Male plates with outer margins convexly rounded to bluntly pointed apices.

This is a common grass-feeding species in meadows and pastures east of the Rocky Mountains.

Illinois Records.—Many males and females, taken April 10 to September 27, are from Adair, Alsip, Alton, Barry, Beach, Carlinville, Cave in Rock, Danville, Dar-

win, Dolson, Dongola, Dubois, Effingham, Eichorn, Elizabethtown, Evergreen Park, Grafton, Golconda, Havana, Karnak, Kin-

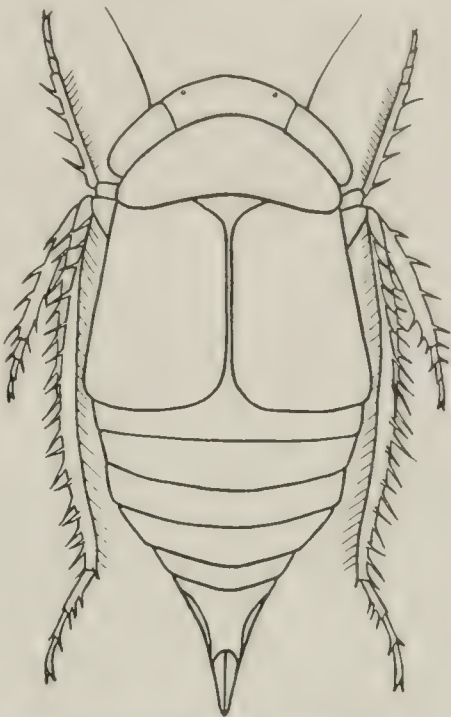


Fig. 403.—*Driotura gammaroides*.

mundy, Marshall, Metropolis, Mozier, Muncie, Niota, Oak Lawn, Oquawka, Parker, Pulaski, Shawneetown, Summit, Thebes, Thomson, Ursa, Vienna, and Zion.

3. *Driotura gammaroides* var. *fulva* Ball

Driotura gammaroides var. *fulva* Ball (1903, p. 231).

The coloration of this variety is reddish brown on vertex, pronotum, the last two segments of abdomen, pygofers, and ventral surface. The elytra and the remainder of the abdominal segments are almost uniform dark brown.

This variety is found in fewer numbers but in the same habitat as typical *gammaroides*.

Illinois Records.—DONGOLA: Aug. 22, 1916, 1 ♀. DUBOIS: Aug. 9, 1917, 1 ♂, 1 ♀. METROPOLIS: Aug. 20, 1916, 2 ♂, 1 ♀. MOZIER: July 28, 1936, Mohr & Burks, 3 ♂, 1 ♀. MUNCIE: cattail bog, Aug. 20, 1936,

B. D. Burks, 1♂. NIOTA: dry bog, July 28, 1936, Mohr & Burks, 1♀. URSA: July 29, 1936, Mohr & Burks, 1♀.

4. *Driotura gammaroides* var. *flava*
Osborn & Ball

Driotura gammaroides var. *flava* Osborn & Ball (1898, p. 90).

Vertex, pronotum, and basal portion of abdomen black. The elytra and last two or three segments of abdomen yellow.

This variety occurs in the same habitats and in association with typical *gammaroides* and var. *fulva*.

Illinois Records.—Males and females, taken June 21 to August 23, are from Barry, Dubois, Evergreen Park, Kinmundy, Metropolis, Oak Lawn, Oquawka, Parker, Thomson, Vienna, and Zion.

71. *ATHYSANELLA* Baker

Athysanella Baker (1898c, p. 185).

Nephotettix Matsumura (1902, p. 378).

Fig. 237. Head wider than pronotum, vertex somewhat produced, obtusely angulate, rounded to front, somewhat depressed on disc. Each hind tibia in male with or without strong spine at apex; spine, if present, about half as long as first tarsal segment.

Ball & Beamer (1940) recorded 45 species of *Athysanella*, including the subgenus *Amphipyga*, from the United States. Most species of this group are distributed from Kansas west to California, but two species of *Amphipyga* are known to occur in Illinois, and at least one *Athysanella* may occur here.

KEY TO SPECIES

1. Each hind tibia of male with spur at apex 1. *robusta*
Each hind tibia of male without apical spur 2
2. Males 3
Females 4
3. Plates, fig. 404A, longer than wide, sinuate on sides; elytra marked with faint lines 2. *acuticauda*
Plates, fig. 404B, wider than long, angled on sides; elytra marked with broad stripes 3. *balli*
4. Seventh sternite broadly emarginate or subtruncate on posterior margin, sometimes indented at middle, and with a broad median longitudinal dark band 2. *acuticauda*

Seventh sternite broadly rounded or subtruncate on posterior margin, distinctly emarginate on inside of lateral angles, and with a very narrow posterior marginal dark band 3. *balli*

1. *Athysanella robusta* Baker

Athysanella robusta Baker (1898c, p. 187).

Length 3.0–3.75 mm. Pale gray, with two shiny black spots near the eyes, also brown spots at apex of vertex and on the disc. Pronotum with three pairs of black dots near the front margin. Elytra with veins whitish, cells somewhat infuscated. Abdomen striped. Female seventh sternite deeply excavated, median lobe about half as long as lateral lobes. Male pygofers rounded, subangulate on posterior borders. Plates short, half as long as pygofers, divergent, rounded posteriorly. Styles elongate, each with two long widely separated spurs curved at tips.

Although this species has not been collected in Illinois, it occurs in Iowa and Nebraska and will probably be found in the western or northwestern part of the state.

Subgenus *Amphipyga* Osborn

Amphipyga Osborn (1928, p. 289).

Vertex short, rounded or slightly angulate, usually with two conspicuous black spots or lines between the ocelli. Males without tibial spurs. Female ovipositor extremely long, extended beyond pygofers. Male pygofers inflated or elongate.

Most of the species of this subgenus are western and only two are known to occur in Illinois. They live on very short grasses and are found abundantly in the plains or short-grass region, or on the short grasses of the barren-appearing sandy plains.

2. *Athysanella (Amphipyga) acuticauda*
Baker

Athysanella acuticauda Baker (1898c, p. 187).

Length 3–4 mm. Dull greenish to brownish, robust. Vertex blunt, angularly or roundedly produced, with a pair of large round black spots extending to front, and with a spot on middle of front visible from above. Elytra usually short, covering only basal two or three segments of abdomen, occasionally reaching almost to tip of abdomen; elytra often striped with brown, abdomen marked with brownish spots and darker

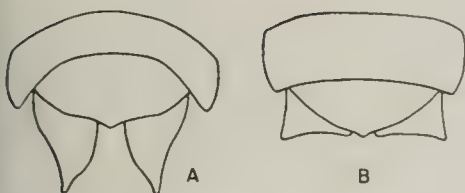


Fig. 404.—*Athysanella*, male plates. A, *acuticauda*; B, *balli*.

areas. Female seventh sternite emarginate posteriorly on either side of a slightly produced broad median lobe. Male plates, fig. 404A, short and broad, divergent, notched on outer margins, apices bluntly pointed.

A common species in dry upland pastures and prairie habitats, *acuticauda* is the most common and widely distributed of all the species of the subgenus. It occurs from Maine to Colorado and Montana.

Illinois Records.—Many males and females, taken May 10 to August 28, are from Apple River Canyon State Park, Evergreen Park, Galena, Grand Detour, St. Anne, Volo, Warren, Wauconda, and Zion.

3. *Athysanella (Amphipyga) balli* (Osborn)

Amphipyga balli Osborn (1928, p. 289).

Length 3 mm. Light gray, resembling *acuticauda* in form and size. Vertex broad, slightly angled and as long as pronotum, with a round black spot on each side of apex extending to front, and with a small black dot at apex. Elytra dark brown, veins white so that elytra appear longitudinally striped. Female seventh sternite truncate or slightly sinuate. Male plates, fig. 404B, short triangular, sinuate on inner margins, apices blunt.

This species has been taken in prairie habitats and in barren sandy areas on sparse patches of short grass. It occurs also on dry upland pastures and in meadows. It was previously recorded from Iowa and Ohio.

Illinois Record.—ALTON: June 27, 1934, DeLong & Ross, 10 ♀.

72. *EXITIANUS* Ball

Exitianus Ball (1929, p. 5).

Fig. 216. Characterized by a bluntly angled vertex, convex between eyes, anterior margin rounded to front, and front not inflated. Venation of elytra simple, apical cells much longer than broad; appendix of each elytron broad. Ovipositor extremely

long, acutely produced, greatly exceeding the slender pygofer.

Only one of the two species of this genus is known to occur in Illinois.

1. *Exitianus obscurinervis* (Stål)

Thamnotettix obscurinervis Stål (1858, p. 293).
Cicadula exitiosa Uhler (1880, p. 72).

Athysanus miniaturatus Gibson (1919, p. 26).

Length 3.5–5.0 mm. Variable in color and markings. Vertex obtusely angled, almost twice as wide at base as median length; vertex pale grayish white, often tinged with orange yellow; ocelli red, a pair of large round black spots on the margin, often a smaller one between these two, also two oblique dashes on basal angles, a transverse crescent mark between the anterior extremities and parallel to the anterior margin. Pronotum with irregular black spots. Triangular spots in basal angles of scutellum brown. Elytra hyaline, nervures dark fuscous.

Female seventh sternite, fig. 287C, with posterior margin subtruncate, slightly, convexly produced at middle. Male plates, fig. 287A, long, narrow, gradually tapering outer margins slightly concave, tips acute, often divergent. Aedeagus as in fig. 287B.

This is a very common and abundant species throughout the United States on several types of plants. It occurs especially on grasses, and attacks many cultivated crops, particularly small grains and legumes.

Illinois Records.—Many males and females, taken May 7 to November 22, are from Alton, Anvil Rock, Bloomington, Bradley, Carman, Cave in Rock, Champaign, Chicago, Collinsville, Danville, Decatur, Dongola, Dubois, East Cape Girardeau, Evergreen Park, Fern Cliff, Gibsonia, Golconda, Grand Detour, Harrisburg, Havana, Herod, High Knob, Jonesboro, Mahomet, Marshall, Mason City, Mederosia, Metropolis, Monmouth, Moweaqua, Niota, Norris City, Oak Lawn, Onarga, Oquawka, Palos Park, Port Byron, Quincy, Springfield, Starved Rock State Park, Thomson, Topeka, Urbana, Vienna, Villa Ridge, Watson, White Heath, and Zion.

73. *EUSCELIS* Brullé

Euscelis Brullé (1832, p. 109).

Body broad and robust. Vertex bluntly and conically produced, disc between eyes

convex, margin thick, rounded to front. Elytra broad, usually shorter than abdomen, second cross nervure often present, apical cells short and broad.

Eight species of this genus are known for the United States, and two are recorded for Illinois. At least one other species may occur here.

KEY TO SPECIES

1. Length not exceeding 4 mm. Each male plate, fig. 407A, truncate at apex; excavation of female seventh sternite, fig. 405A, with a prominent apical tooth. **1. relativus**
Length 5 mm. or more. Each male plate not truncate at apex; tooth in excavation of female seventh sternite, if present, very small. 2
2. Vertex, fig. 405B, broadly rounded, less than half as long at middle as width between eyes. Each male plate, fig.

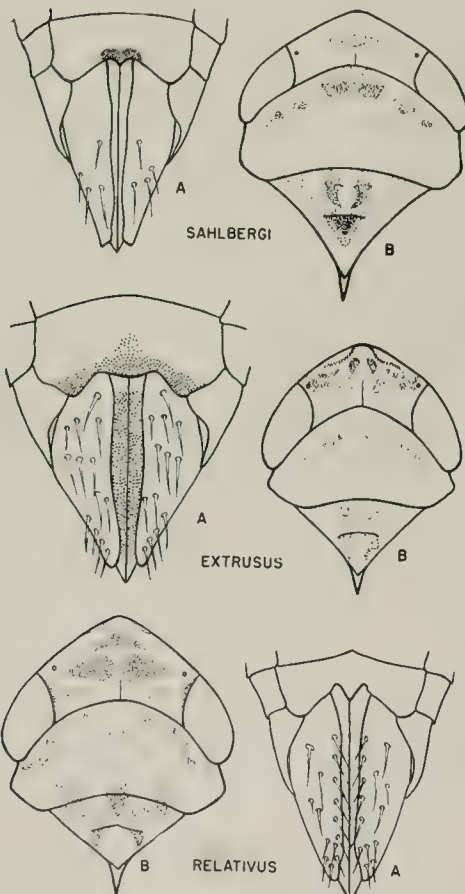
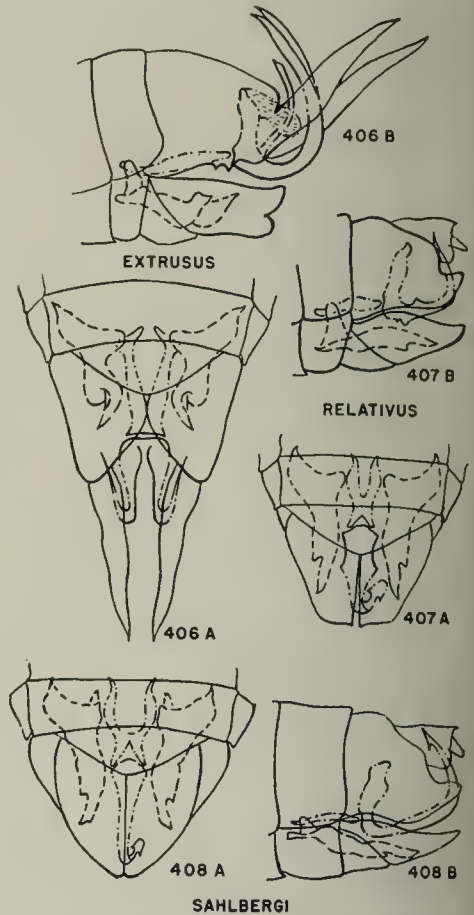


Fig. 405.—*Euscelis*. A, female genitalia; B, head and pronotum.



Figs. 406–408.—*Euscelis*, male genitalia, A, ventral aspect; B, lateral aspect.

408A, with bluntly rounded apex; excavation of female seventh sternite, fig. 405A, angular and with a minute black tooth. **2. sahlbergi**
Vertex, fig. 405B, obtusely angled, almost three-fourths as long at middle as width between eyes. Each male plate, fig. 406A, with blunt divergent apex. Female seventh sternite, fig. 405A, with basal margin of excavation broadly and roundedly produced. **3. extrusus**

1. *Euscelis relativus* (Gillette & Baker)

Athymanus relativus Gillette & Baker (1895, p. 93).

Length 4 mm. Short, stout, pale brownish to straw colored, marked with fuscous. Vertex, fig. 405B, obtusely angled, a little more than half as long as basal width between the eyes, often with a few irregular pale markings. Ocelli red. Elytra subhya-

line, nervures indistinct. Female seventh sternite, fig. 405*A*, with lateral angles rounded to posterior margin, which is rather deeply and roundedly excavated; apex with a black acutely pointed tooth. Male plates, figs. 407*A*, 407*B*, about as long as combined basal width, narrowed to about half their width at apexes, which are broad and truncate.

This is a grass-feeding species recorded from the northeastern states. It has been taken from timothy, and apparently its habitat conditions are quite similar to those of *extrusus* and *sahlbergi*.

2. *Euscelis sahlbergi* (Reuter)

Athysanus sahlbergi Reuter (1880, p. 220).
Euscelis deceptus Sanders & DeLong (1917, p. 87).

Length 5.5–6.0 mm. Yellowish, marked with brown. Vertex, fig. 405*B*, broadly rounded, more than twice as wide between eyes as median length; with irregular transverse brown markings. Ocelli red. Pronotum and scutellum with irregular brown spots. Elytra dull yellow, with indistinct nervures and brownish markings. Female seventh sternite, fig. 405*A*, with lateral angles rounded to a broadly and angularly excavated posterior margin that bears at its apex a short median black tooth. Male plates, figs. 408*A*, 408*B*, broad, convexly rounded to blunt apexes.

This species occurs in the New England states and west to South Dakota, and is found in fresh-water marshes.

Illinois Records.—DES PLAINES: Sept. 4, 1935, Frison & DeLong, 1 ♂. FOX LAKE: June 26, 1936, Frison & DeLong, 2 ♂, 1 ♀; June 30, 1935, DeLong & Ross, 1 ♂; Aug. 12, 1937, Ross, 3 ♂. GRAYS LAKE: June 10, 1936, Ross & Burks, 1 ♂, 1 ♀. OAK LAWN: summer, 1934, at light, 1 ♀. VOLO: in bog, June 11, 1936, Ross & Burks, 1 ♂. ZION: July 16, 1935, DeLong & Ross, 1 ♀.

3. *Euscelis extrusus* (Van Duzee)

Athysanus extrusus Van Duzee (1893, p. 283).

Length 5–6 mm. Broad, stout, yellowish, with dark markings. Vertex, fig. 405*B*, obtusely angled, almost three-fourths as long as width between eyes, with a pair of oblique fuscous spots at apex and a transverse spindle-shaped spot between eyes. Pronotum and scutellum with irregular

markings. Elytra pale yellow, nervures paler, areoles margined with fuscous; in pale specimens, markings often faint or wanting. Female seventh sternite, fig. 405*A*, with lateral lobes pointed, posterior margin rather broadly and deeply excavated, the margin of excavation slightly produced at middle. Male plates, figs. 406*A*, 406*B*, with outer margins sloping, inner margins divergent, forming blunt almost rounded apexes.

This species, previously recorded from the northeastern states, occurs in moist habitats on grasses. It has been taken in low wet pastures and meadows and is frequently found in fresh-water marshes.

Illinois Records.—ELIZABETH: July 7, 1917, 1 ♀. GRAND DETOUR: July 2, 1934, DeLong & Ross, 1 ♀. OAKWOOD: May 30, 1932, T. H. Frison, 1 ♀. OREGON: June 21, 1917, 1 ♀; June 30, 1935, DeLong & Ross, 3 ♂, 1 ♀. URBANA: June 18, 1889, 1 ♀; May 1, 1890, C. A. Hart, 1 ♀; June 2, 1890, C. A. Hart, 1 ♀; July 27, 1891, Marten, 1 ♂; July 29, 1891, Terrill, 1 ♂.

74. *OPHIOLA* Edwards

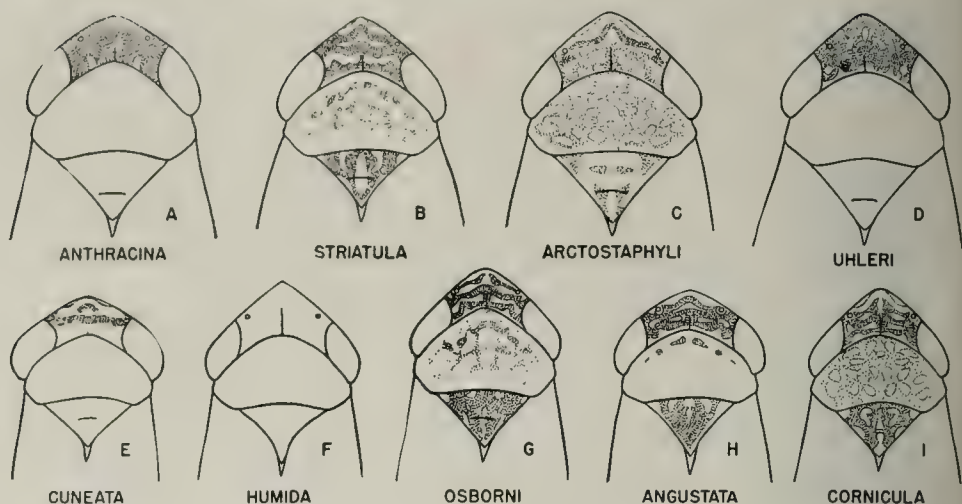
Ophiola Edwards (1922, p. 206).

Vertex produced before anterior margins of eyes, acutely conical, disc not strongly convex between eyes, sloping regularly from pronotum to apex. Form small, narrow, and elongate.

The 20 or more species of this genus are usually found in bogs or heaths, occurring on *Vaccinium*, *Arctostaphylos*, and *Symphoricarpos*; probably a few species occur in marsh habitats. Five species are recorded for Illinois, and at least four others may occur in this state.

KEY TO SPECIES

1. Elytra short, reaching tip of or only slightly exceeding abdomen; apical cells relatively short.....2
Elytra longer, definitely longer than abdomen; apical cells long and narrow...5
2. Length 4.0 mm. or more.....3
Length not exceeding 3.5 mm.....4
3. Color shiny black, vertex, fig. 409*A*, broadly rounded, scarcely longer at middle than next to eyes.....*1. anthracina*
Dark in color, not shiny black, vertex, fig. 409*D*, with yellowish lines or spots, distinctly longer at middle than next to eyes.....*2. uhleri*
4. Vertex, fig. 409*F*, sulfur yellow, without definite markings.....*3. humida*

Fig. 409.—*Ophiola*. A–I, heads and pronota.

- Vertex, fig. 409C, tawny, with three transverse fuscous bands.....
5. Vertex, fig. 409E, scarcely longer at middle than next to eyes, marked with one black transverse band; length not exceeding 3.5 mm.....
- Vertex definitely longer at middle than next to eyes, with three transverse bands or indefinite markings; length exceeding 4.0 mm.....
6. Slender, elongate; elytra long, greatly exceeding abdomen in length; abdomen reaching about to apex of clavus.....
- Broader, more robust, not slender; elytra not greatly exceeding abdomen, latter extending to about cross nervures of apical cells.....
7. Vertex, fig. 409I, distinctly and obtusely angled, twice as long at middle as next to eyes and with three distinct dark transverse bands; length 4.5 mm.....
- Vertex, fig. 409H, broadly rounded, one-half longer at middle than next to eyes; markings indefinite, bands not distinct; length not exceeding 4.0 mm.....
8. Color olive; fore and middle femora twice banded with white.....
- With a definite orange coloration; fore and middle femora shiny black, abruptly orange at apexes, tibia orange.....

1. *Ophiola anthracina* (Van Duzee)

Athysanus anthracinus Van Duzee (1894a, p. 136).

Length 4 mm. Small, robust, shiny black. Vertex, fig. 409A, obtusely conical, two-thirds as long as width between eyes, with

two spots on posterior margin farther from each other than from the eyes. Female seventh sternite, fig. 410C, with posterior margin slightly and roundedly produced. Male plates, figs. 410A, 410B, triangular, longer than combined basal width, convexly rounded to sharp-pointed apices.

This is a meadow species and is also found on herbaceous plants in wooded or shaded areas in the northeastern states and west to Colorado.

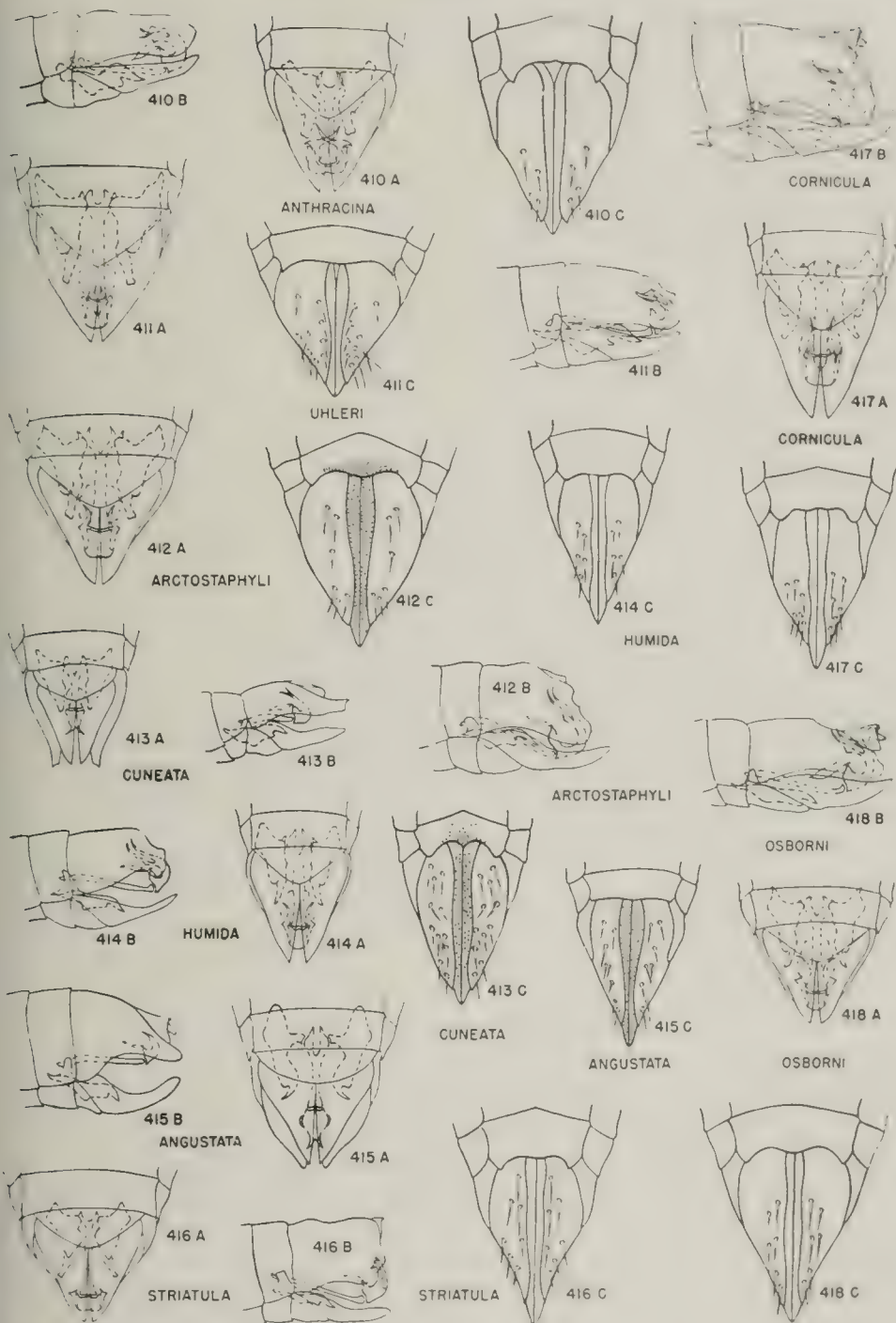
Illinois Records.—EICHORN: June 24, 1932, Ross, Dozier, & Park, 1 ♀. HAVANA: sand prairie, Nov. 17, 1913, 4 nymphs. NORMAL: June 22, 1883, 1 ♂, 2 ♀. NORTH-EARN ILLINOIS: 2 ♂, 3 ♀. RISING: July 16, 1888, C. A. Hart, 1 ♀. ST. JOSEPH: June 27, 1915, 1 ♂. THEBES: July 11, 1935, DeLong & Ross, 1 ♀. URBANA: June 13, 1889, C. A. Hart, 1 ♂; June 30, 1889, 1 ♂. VIENNA: June 14, 1934, DeLong & Ross, 1 ♂, 8 ♀; July 29, 1934, DeLong & Ross, 1 ♀.

2. *Ophiola uhleri* (Ball)

Athysanus uhleri Ball (1911, p. 200).

Athysanus plutonius Provancher (1889, p. 282). Misidentification of *plutonius* Uhler.

Length 4 mm. Broad, robust, black to brownish. Vertex, fig. 409D, distinctly angled, twice as wide between eyes as median length; a line on posterior margin of vertex, an oblique spot against either eye, and a pair of median apical spots yellowish. Elytra short and broad, truncate posteri-



Figs. 410-418.—*Ophiola*. A, ventral aspect of male genitalia; B, lateral aspect of male genitalia; C, female genitalia.

orly, usually dark, nervures occasionally paler. Female seventh sternite, fig. 411C, with posterior margin roundedly produced, lateral angles bluntly rounded. Male plates, figs. 411A, 411B, triangular, longer than combined basal width, convexly rounded to rather broad pointed apices.

Ranging through the northeastern states and west to Colorado, this species occurs in wet meadow associations.

Illinois Records.—ANTIOCH: July 5-7, 1932, T. H. Frison, 1 ♂. KANKAKEE: July 20, 1934, DeLong & Ross, 1 ♀. VOLO: July 27, 1934, DeLong & Ross, 1 ♀.

3. *Ophiola humida* (Osborn)

Athysanus humidus Osborn (1915, p. 131).

Length 3.5 mm. Resembling *arctostaphyli* but with a yellowish unmarked head. Vertex, fig. 409F, obtusely angled, a little more than twice as long at middle as next to eyes. Pronotum and scutellum yellow, with faint fuscous markings. Elytra pale brown, subhyaline, nervures pale, bordered with fuscous. Female seventh sternite, fig. 414C, with rounded lateral angles, between which the posterior margin is almost truncate. Male plates, figs. 414A, 414B, triangular, longer than combined basal width, gradually narrowed to pointed apices.

This species has been taken only in bog habitats in Maine and Wisconsin. It should occur in bogs in the northeastern part of Illinois.

4. *Ophiola arctostaphyli* (Ball)

Athysanus arctostaphyli Ball (1899a, p. 172).

Length 3.5 mm. Tawny yellow, with transverse fuscous markings on the head. Vertex, fig. 409C, bluntly angled, a little more than one-half as long at middle as width between eyes; anterior transverse mark produced forward in a loop toward apex, second almost straight, and the basal one is confluent with the second by a common area on median line. Scutellum with fuscous spots in basal angles and a pair of bilobed spots on disc. Elytra testaceous subhyaline, nervures pale, heavily bordered with fuscous.

Female seventh sternite, fig. 412C, with lateral angles produced, between which the posterior margin is slightly produced on either side of the produced median third. Male plates, figs. 412A, 412B, triangular,

gradually narrowed to rather sharp-pointed apices.

This is primarily a heath species reported from the northeastern states. Also it has been collected from the bearberry, *Arctostaphylos*, in Colorado. This plant is found growing along the shores of Lake Michigan in Illinois, and *arctostaphyli* may at some time be found there.

5. *Ophiola cuneata* (Sanders & DeLong)

Euscelis cuneata Sanders & DeLong (1920, p. 17).

Length 3.0-3.5 mm. Small, wedge-shaped, greenish yellow. Vertex, fig. 409E, almost parallel margined, slightly and roundedly produced, with black transverse band between eyes just back of ocelli. Elytra distinctly longer than abdomen, smoky subhyaline, nervures yellowish. Female seventh sternite, fig. 413C, with prominent lateral angles, posterior margin strongly produced on either side of a dark median obtuse tooth. Male plates, figs. 413A, 413B, long, tapering gradually to acute tips.

This species is common in the eastern states in moist habitats at lagoon margins in the *Juncus-Cyperus* association. In general appearance, it resembles some species of *Limotettix*, especially *striolus*, with which it is often collected.

6. *Ophiola cornicula* (Marshall)

Jassus corniculus Marshall (1866, p. 198).

Jassus orichalceus Thomson (1869, pp. 56, 72).

Jassus plutonius Uhler (1877, p. 470).

Athysanus instabilis Van Duzee (1893, p. 284).

Athysanus elongatus Osborn (1915, p. 129).

Length 4.5 mm. Narrow, yellowish, with long elytra. Vertex, fig. 409I, distinctly angled, more than one-half as long at middle as width between the eyes, with three dark transverse lines as in *arctostaphyli*, lines heavier than in that species, the basal one extending forward near each eye and touching the median band. Elytra greatly exceeding abdomen, testaceous, subhyaline, nervures pale, heavily margined with fuscous.

Female seventh sternite, fig. 417C, with posterior margin slightly and roundedly produced. Male plates, figs. 417A, 417B, triangular, gradually narrowed to pointed apices.

This species has been taken in the *Juncus-Cyperus* fresh-water marsh habitat, espe-

cially in the northeastern states, but no other detailed habitat records are available.

Illinois Record.—CHEMUNG: Aug. 13, 1937, 1 ♀.

7. *Ophiola angustata* (Osborn)

Athysanus angustatus Osborn (1915, p. 130).

Length 4 mm. Greenish yellow to brownish, resembling *cornicula*. Vertex, fig. 409H, broadly rounded, more than twice as wide between eyes as length at middle, with irregular markings. Elytra with nervures pale, bordered with fuscous.

Female seventh sternite, fig. 415C, almost truncate on posterior margin, lateral angles very blunt, not produced. Male plates, figs. 415A, 415B, triangular, slightly concave on apical halves, apices acutely pointed.

This species is northern in distribution.

8. *Ophiola striatula* (Fallen)

Cicada striatula Fallen (1826, p. 45).

Athysanus vaccinii Van Duzee (1890a, p. 135).

Length 4.0–4.5 mm. Olivaceous yellow. Vertex, fig. 409B, obtusely angled, twice as wide between eyes as median length, with three transverse black bands. Elytra longer than abdomen, testaceous, subhyaline, nervures white, tinted with olive, heavily margined with fuscous. Female seventh sternite, fig. 416C, with lateral angles produced, bluntly acute, between which the posterior margin is broadly and concavely rounded and slightly produced at middle. Male plates, figs. 416A, 416B, triangular, as long as combined basal width, apices bluntly pointed.

This species occurs in Europe and North America; in the United States it ranges from Maine to Colorado. It has been taken from *Vaccinium* in bogs. It is quite variable in coloration, size, and markings.

Illinois Records.—LONG LAKE: Aug. 11, 1906, 4 ♂, 11 ♀. NORMAL: June 27, 1883, 1 ♂, 1 ♀. VOLO: July 8, 1932, Ross, Dozier, & Mohr, 1 ♂, 1 ♀; July 27, 1934, DeLong & Ross, 17 ♂, 8 ♀; in bog, Aug. 24, 1935, 1 ♂, 10 ♀.

9. *Ophiola osborni* Ball

Ophiola osborni Ball (1928, p. 190).

Length 4.0–4.5 mm. In general appearance similar to *symphoricarpeae* Ball but

slightly smaller and darker in color. Pale brownish. Vertex, fig. 409G, twice as wide as median length, tinted with red and with three transverse dark bands. Elytra testaceous subhyaline, nervures pale, heavily bordered with fuscous. Front dark, with faint orange arcs. Femora usually dark to near apices, then orange, as are the tibiae. Female seventh sternite, fig. 418C, with lateral angles bluntly rounded, between which the posterior margin is broadly and concavely rounded, with the median third slightly produced. Male genitalia as in figs. 418A, 418B.

Distributed from Maine and Maryland west to Colorado and Montana, this is an upland species occurring in dry habitats.

Illinois Records.—FAIRFIELD: June 12, 1934, DeLong & Ross, 1 ♀. ST. ANNE: Aug. 21, 1934, DeLong & Ross, 1 ♀.

75. *Opsius* Fieber

Opsius Fieber (1866, p. 505).

Vertex short, broadly rounded, and somewhat produced, almost parallel margined, rounded to front, without a definite margin. Elytra long, without extra costal veinlets.

Only one species of the genus is known to occur in the United States, and it is abundant throughout Illinois.

1. *Opsius stactogalus* Fieber

Opsius stactogalus Fieber (1866, p. 505).
Eutettix osborni Ball (1907, p. 39).

Length 4.0–4.5 mm. Pale green, flecked with white on elytra. Vertex rounded. Pronotum darker green than elytra, irregularly mottled on disc, paler anteriorly. Elytra dark green to apex of each clavus, apical portions smoky, subhyaline; an irregular white band between the green and smoky portions, a round white spot in the apex of the central anteapical cell, and several irregular white flecks on the green portion. Female seventh sternite with posterior margin rounded and slightly produced at middle. Male plates triangular, gradually narrowed to acutely pointed apices. Aedeagus as in fig. 288B.

This transcontinental species is widespread and abundant. It is commonly found on the ornamental tamarisk, which is apparently its only known food plant.

Illinois Records.—HARRISBURG: at light, June 15, 1934, DeLong & Ross, 1 ♂, 3 ♀.

HAVANA: July 2, 1934, DeLong & Ross, 1 ♀. KANKAKEE: at light, July 22, 1935, DeLong & Ross, 2 ♂, 5 ♀. ONARGA: Aug. 29, 1934, DeLong & Ross, 1 ♂. URBANA: June 19, 1934, H. H. Ross, 5 ♂, 11 ♀.

76. *LIMOTETTIX* Sahlberg

Limotettix Sahlberg (1871, p. 224).

Drylix Edwards (1922, p. 207).

This genus is characterized by a short vertex, not extremely broad, which is slightly produced, almost parallel margined, rounded to front. Ocelli distinctly below the level of vertex. Venation of elytra simple, apical cells elongate.

The species belonging to this genus are all found on the grasses and sedges in the fresh-water marsh and are very similar in appearance. Nine species are recorded for the United States. At least three of these are known to occur in Illinois, and several others may occur here.

KEY TO SPECIES

1. Vertex slightly produced; male plates triangular or elongate, not excavated on inner margins near apex, as in fig. 419G; female seventh sternite broadly and concavely excavated, as in fig. 419B... 2
- Vertex not produced, almost parallel margined; each male plate excavated on inner margin near apex, or short, truncate, or broadly rounded at apex, as in fig. 419M; female seventh sternite with only median third notched or excavated, as in fig. 419C... 3
2. Male plates, fig. 419G, elongate, more than one-half longer than combined basal width; female seventh sternite, fig. 419B, rather broadly, angularly excavated half the distance to base... 1. *utahnus*
- Male plates, figs. 419F, 419J, shorter, triangular, not longer than combined basal width; female seventh sternite, fig. 419D, broadly, shallowly excavated not more than one-third the distance to base... 2. *striolus*
3. Male plates, figs. 419L, 419M, concave on inner margins before each apex, apices convergent, caliper-like; female seventh sternite, fig. 419C, shallowly, angularly notched on median third... 3. *divaricatus*
- Male plates short, truncate, or broadly rounded at apices; female seventh sternite concavely rounded on median third... 4
4. Male plates, figs. 419E, 419I, very short, with apices broadly truncate; female seventh sternite slightly concave on posterior margin on either side of median excavation... 4. *truncatus*

Male plates, figs. 419H, 419K, longer, apices broadly rounded; posterior margin of female seventh sternite, fig. 419A, strongly, convexly rounded on either side of median excavation... 5. *parallelus*

1. *Limotettix utahnus* (Lawson)

Drylix utahnus Lawson (1931b, p. 590).

Length 5.0–5.5 mm. Resembling *striolus*; vertex but slightly produced at middle, a little more than twice as wide as long, yellow, with the usual black transverse bands. Pronotum dirty yellow, with signs of brownish mottling on anterior third. Elytra smoky yellow, nervures paler, cells smoky to brown. Face yellow, with arcs of the front and sutures black. Female seventh sternite, fig. 419B, with the posterior margin broadly, concavely rounded about half way to base. Male plates, fig. 419G, triangular and very long, their bluntly pointed apices greatly exceeding pygofers.

This is a fresh-water marsh species, reported previously from the Rocky Mountain region, that has been taken in the western part of Illinois.

Illinois Record.—MORRIS: June 18, 1938, Williams, 1 ♂, 1 ♀.

2. *Limotettix striolus* (Fallen)

Cicada striola Fallen (1806, p. 31).

Length 4–5 mm. Greenish yellow, wedge shaped. Vertex slightly produced, not quite twice as wide as median length, with a transverse black band just back of ocelli. Elytra pale greenish hyaline, nervures pale. Female seventh sternite, fig. 419D, with lateral margins obliquely sloping, posterior margin broadly and concavely excavated. Male plates, figs. 419F, 419J, about as long as combined basal width, convexly rounded to bluntly angled apices.

This is a common fresh-water marsh and swamp species that ranges from the north-eastern states to Colorado and occurs in the *Juncus-Cyperus-Phragmites* association.

Illinois Records.—Many males and females, taken May 2 to October 5, are from Algonquin, Antioch, Aurora, Beach, Cave in Rock, Cedar Lake, Champaign, Dixon, Elgin, Evergreen Park, Fox Lake, Freeport, Fulton, Galena, Havana, Herod, McHenry, Oak Lawn, Orangeville, Palos Park, Putnam, Sheffield, Thomson, Urbana, Vienna, Volo, Waukegan, and Zion.

3. *Limotettix divaricatus* (Sanders & DeLong)

Euscelis divaricatus Sanders & DeLong (1923, p. 151).

Length 5.5 mm. Greenish yellow, resembling *parallelus*. Vertex almost parallel, not produced, with black transverse band just

4. *Limotettix truncatus* Slesman

Drylix truncatus Slesman (1930, p. 100).

Length 5.0–5.5 mm. Greenish yellow, resembling *parallelus*. Vertex broad, almost parallel margined, not produced, with the usual broad black band just back of ocelli. Anterior margin of pronotum narrowly

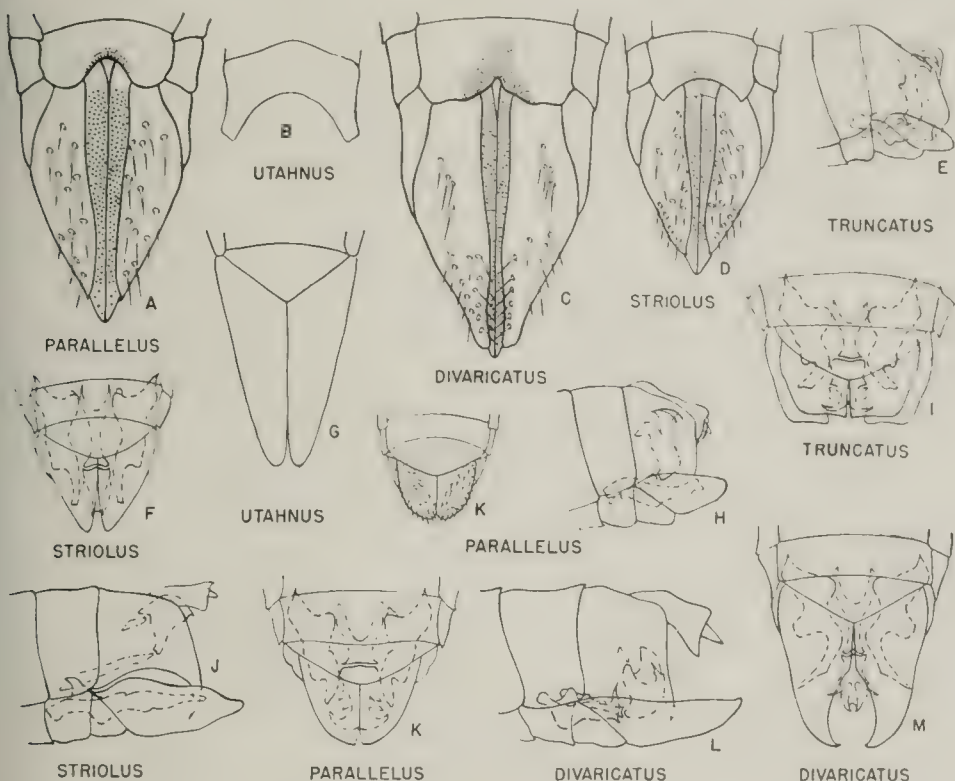


Fig. 419.—*Limotettix*. A–D, female genitalia; E–M, male genitalia, ventral and lateral views.

back of ocelli, and a small spot at apex. Elytra smoky. Female seventh sternite, fig. 419C, with posterior margin almost truncate, slightly and angularly excavated on median third. Male plates, figs. 419L, 419M, about one-half longer than combined basal width, the outer margins convexly rounded, inner margins concavely rounded on apical half to form widely divergent acutely pointed tips; these appear caliper-like when viewed ventrally.

This is a rather scarce fresh-water marsh species that apparently occurs in widely separated areas. It is recorded from Pennsylvania and Idaho, and may eventually be taken in Illinois.

black, a broad transverse black band on disc of posterior half. Disc of scutellum black, a black spot in each basal angle. Elytra dark, nervures pale. Female seventh sternite with median third of posterior margin shallowly concave between the lateral margins and the sharp point where the median excavation meets the posterior margin. Male genitalia as in figs. 419E, 419I.

A fresh-water marsh species taken in small numbers, *truncatus* is known only from the central states. Apparently it is not so abundant as *striolus* and *parallelus*.

Illinois Records.—ODIN: May 28, 1910, 1 nymph; May 30, 1910, 6♂, 3♀. URBANA: July 2, 1889, C. A. Hart, 20♂, 15♀; July

15, 1889, Terrill, 2 ♀; Aug. 15, 1890, Miss Snyder, 8 ♂, 4 ♀.

5. *Limotettix parallelus* (Van Duzee)

Athysanus parallelus Van Duzee (1891, p. 169).

Length 6 mm. Pale yellowish or greenish, resembling *striolus* but larger. Vertex distinctly parallel margined, not produced, with a broad black band just back of ocelli. Elytra subhyaline, nervures with yellowish tint. Female seventh sternite, fig. 419A, with posterior margin truncate, a broad U-shaped notch on median third extending about half way to base. Male plates, figs. 419H, 419K, three-fourths as long as basal width, gradually narrowed to rather broad rounded apices.

This species is found commonly in association with *striolus* in the fresh-water marsh on the *Juncus-Cyperus-Phragmites* association. Its range is from the northeastern states to Colorado.

Illinois Records.—BEACH: swamps, Aug. 21, 1906, 3 ♂, 5 ♀. MCHENRY: July 27, 1934, DeLong & Ross, 3 ♂, 10 ♀. PRINCETON: July 7, 1934, DeLong & Ross, 6 ♂, 7 ♀; July 2, 1936, B. D. Burks, 2 ♂; June 28, 1937, Ross & Burks, 7 ♂, 5 ♀; July 2, 1937, Mohr & Burks, 1 ♀. ZION: July 16, 1935, DeLong & Ross, 1 ♂, 1 ♀.

77. *THAMNOTETTIX* Zetterstedt

Thamnotettix Zetterstedt (1838, col. 292).

Fig. 209. Vertex bluntly angled and also bluntly angled with front. Elytra with one crossvein between the first and second sectors. Second anteapical cell elongate, constricted at middle.

Although a large number of North American species have been described in or placed in *Thamnotettix*, most of these have been placed more recently in other genera because of the revised definition of the characteristics of this genus. At present, this genus contains only one species.

1. *Thamnotettix simplex* (Herrich-Schaeffer)

Jassus simplex Herrich-Schaeffer (1833, fasc. 125, p. 7).

Deltocephalus chlamydatus Provancher (1890, p. 339).

Length 5.5 mm. Dull olive green or brownish green, quite variable in shade and

intensity of color. Vertex paler, with an indistinct band on anterior portion between ocelli. Pronotum darker on disc and posterior margin. Scutellum with a pair of black spots on disc, basal angles black. Elytra smoky to brown, tinged with green.

Female seventh sternite slightly concave, slightly indented on either side of median third. Male valve triangular, plates a little longer than combined basal width, apices blunt, rounded to inner margins.

A European species commonly distributed in the northern and northeastern portions of the United States and Canada, *simplex* occurs on shrubby and herbaceous growth. It should occur in northern Illinois.

78. *MENOSOMA* Ball

Menosoma Ball (1931b, p. 4).

Fig. 219. Vertex broad, obtuse, sloping, usually a little longer on median line than next to eye; in lateral view rounded over to front to form an obtusely conical apex. Venation of elytra simple, second cross nervure of each absent, the two outer apical veinlets reflexed and expanded on the costa.

Only one of the two known species of this genus occurs in Illinois.

1. *Menosoma cincta* (Osborn & Ball)

Eutettix cincta Osborn & Ball (1898, p. 97).

Length 5.5–6.0 mm. Greenish yellow, marked with brown. Vertex bluntly conical, almost one-half longer at middle than next to eyes, tinted with saffron. Pronotum irrorate. Scutellum pale, a pair of small spots on disc and a spot on each lateral margin. Elytra tinted with saffron, nervures red; a broad brownish band across posterior half of each clavus and obliquely extending back to costa; cross nervures on clavus broadly black, costal nervures black, and an area in the third apical cell sometimes black. Female seventh sternite with the posterior margin slightly rounded, a little produced at middle. Male plates long, broad at bases, concavely narrowed to slender upturned apices.

Distributed throughout the eastern states and west to Colorado, this is a common species, especially on herbaceous vegetation in wooded or shaded areas.

Illinois Records.—Many males and females, taken June 14 to November 17, are from Aldridge, Alton, Apple River Canyon

State Park, Cave in Rock, Danville, Dixon Springs, Dubois, Elizabethtown, Fern Cliff, Grand Detour, Grand Tower, Heathsville, Herod, Horseshoe Lake, Kankakee, Karnak, Metropolis, Oakwood, Rosiclare, St. Anne, Shawneetown, Temple Hill, Urbana, Vienna, Warren, Waukegan, and White Pines Forest State Park.

79. *ORIENTUS* DeLong

Orientus DeLong (1938c, p. 217).

Resembling *Paraphlepsius* by having ramose pigmented lines but with head conspicuously narrower than pronotum. Vertex transversely impressed behind apex. Lateral margins of pronotum strongly angulate. Elytron with one crossvein between first and second sectors.

Only one North American species of this genus has been recognized.

1. *Orientus ishidae* (Matsumura)

Phlepsius ishidae Matsumura (1902, p. 382).
Phlepsius tinctorius Sanders & DeLong (1919, p. 235).

Length of female 6 mm., male 5 mm. Vertex one-fourth wider than long, almost evenly rounded and parallel margined, with apex narrowly but decidedly inflated before a distinct depression; color ivory white, with small irregular black spot on either side of apex, an irregular semicircular black spot above each ocellus, and a large quadrangular orange spot on either side of median dark line, spot margined with irregular black lines. Pronotum short and broad, truncate posteriorly, with distinct flaring lateral angles, broader than head; color tawny, shading to darker, generally marked with vermicular brown lines. Scutellum nearly all orange, marked with brown, also an ivory spot on posterior margin midway between apex and lateral angle. Elytra milky, with pale tawny areas; tip of each clavus, margin of apex, and spots on costal margin dark brown. Face dark brown, with many pale spots.

Female seventh sternite smoothly truncate. Male valve, fig. 242, broadly and bluntly angled; plates long, triangular, evenly tapering to long curved tips, each laterally lobed before the apex.

Known in the United States only from New Jersey, this species has been taken on *Aralia spinosa*.

80. *MESAMIA* Ball

Mesamia Ball (1907, pp. 31, 59, 75).

Fig. 295. Vertex with the disc depressed, anterior margin usually elevated and acutely angled with the front, margin often slightly produced. Elytra with second cross nerve present, but sometimes obscure, and the central anteapical cell slightly constricted. Usually with several supernumerary veinlets along the clavus and costa.

Beamer (1942) recognized 15 species as belonging to this genus, nearly all of which are found only in the western United States. One species has been taken in Illinois, and two others may eventually be found here. They seem to be associated with the prairie habitat.

KEY TO SPECIES

1. A dark broad saddle on each elytron between the cross nervures.....**1. nigridorsum**
Each elytron without a dark saddle spot.....**2**
2. Vertex depressed, with four spots on anterior margin, these connected by a line posteriorly; a broad dark band below vertex. Length 4.5-5.5 mm.....**2. straminea**
Vertex flat, with a narrow line above and another below margin. Length 3.7-4.5 mm.....**3. coloradensis**

1. *Mesamia nigridorsum* Ball

Mesamia nigridorsum Ball (1907, p. 60).

Length 4-5 mm. Milky white, marked with black. Vertex with margin ivory white, disc brown, a black line between ocelli anterior to which is a quadrate black spot on either side of median line. Face black. Pronotum with disc and anterior margin brown, these areas separated by a white transverse band. Elytra milky white, nervures brown, a dark brown or black saddle across the posterior two-thirds of each clavus, usually a narrow band at base and apex of clavus; costal veinlets black.

Female seventh sternite broadly, angularly excavated with a short median tooth about as long as its basal width, slightly bifid at apex. Male plates, fig. 294, a little longer than their combined basal width, narrowed slightly and concavely to acute apices.

Distributed through the eastern states and west to Utah, this conspicuously marked species occurs abundantly on the prairie on

Helianthus and produces black spots by its feeding punctures.

Illinois Records.—Many males and females, taken June 9 to October 31, are from Aldridge, Champaign, Des Plaines, Dubois, East St. Louis, Evergreen Park, Havana, Kimbundy, La Rue, Muncie, Niota, Oak Lawn, Palos Park, Princeton, St. Anne, Shawneetown, Starved Rock State Park, Summit, Urbana, Vienna, Waukegan, White Pines Forest State Park, Wolf Lake, and Zion.

2. *Mesamia straminea* (Osborn)

Paramesius straminea Osborn (1898, p. 241).

Length 4.5–5.5 mm. General color greenish to straw, with dark veins. Anterior and posterior margins of vertex ivory white, with an irregular black line interrupted at the middle, this sometimes reduced to four black spots behind the anterior margin. Pronotum with anterior half pale and posterior portion brownish. Elytra subhyaline, tinted with pale brown, three pairs of milky white spots along suture; nervures brown, costal veinlets fuscous. Face pale, a narrow black band just beneath vertex. Female seventh sternite with a sunken tooth as in *nigridorsum*. Male plates acutely pointed as in that species.

This insect occurs on a species of *Helianthus* and is found on the prairies in the Middle West and California.

3. *Mesamia coloradensis* (Gillette & Baker)

Allygus coloradensis Gillette & Baker (1895, p. 91).

Paramesius immaculatus Ball (1905, p. 211).

Length 3.7–4.5 mm. Resembling pale specimens of *straminea*, but smaller and with a flatter vertex. Vertex not produced but acutely angled with the front; usually marked by a fine black line on margin, interrupted at middle, and often with two black spots at base. Pronotum pale, with variable markings, disc irregularly irrorate, often spots near eyes; often without markings. Elytra short, strongly reticulate veined; greenish white to greenish brown, with dark nervures. Female seventh sternite with posterior margin shallowly and angularly excavated on either side of the median fifth, which is produced into a broad tooth as long as its basal width and notched at apex.

Male plates small, a little longer than basal width, concavely narrowed to acute apices.

This species occurs in Colorado and Utah; records for other areas are doubtful. It might be found in the western portion of Illinois.

81. *ALIGIA* Ball

Aligia Ball (1907, pp. 31, 53, 75).

Fig. 214. Head short, vertex rounded to front, a faint transverse curved depression between ocelli. Elytra long, usually subhyaline, nervures distinct, two cross-veins between first and second sectors and usually a number of veinlets in costal cell and next to claval suture.

Most of the 33 described species and subspecies of the genus, as recognized by Hepner (1939), occur only in the West or Southwest. One species, *modesta*, occurs in the Ohio River valley and has been taken in Illinois.

1. *Aligia modesta* (Osborn & Ball)

Eutettix modesta Osborn & Ball (1898, p. 98).

Length 4.5–5.5 mm. Fulvous, with a pair of tawny spots near apex of vertex and a pair of oblique marks inside the basal angles. Pronotum faintly irrorate with tawny. Elytra white, subhyaline, tinted with reddish fulvous, interrupted by two pale bands, an indefinite basal band and a narrow definite one across the second cross nervure. Female seventh sternite almost truncate, with a broad slightly rounded median projection. Male plates long, spoon shaped.

Distributed through the eastern half of the United States, this species is usually found on oak and is easily obtained in cut-over areas where oak shrubs grow abundantly.

Illinois Records.—CAVE IN ROCK: Oct. 2, 1934, Frison & Ross, 1♂. DIXON SPRINGS: July 9, 1935, DeLong & Ross, 1♀. DOLSON: July 24, 1936, DeLong & Mohr, 1♂. ELIZABETHTOWN: July 8, 1935, DeLong & Ross, 1♂. LA RUE: July 11, 1935, DeLong & Ross, 1♂, 3♀; Oct. 4, 1934, Frison & Ross, 1♂.

82. *NORVELLINA* Ball

Norvellina Ball (1931b, p. 2).

Fig. 229. Vertex broader than long, almost parallel margined, broadly rounded

to or slightly angulate with front. Venation simple, with one crossvein between the sectors, without true costal veinlets except the two at the ends of the first apical cell. Elytra covered by a saddle pattern of pigmented reticulate lines and veins.

Lindsay (1940) recorded for this genus 29 species and subspecies, chiefly western in distribution, as occurring in the United States. Four species are known from Illinois.

KEY TO SPECIES

1. Greenish yellow, often tinted with brown, but elytra without definite oblique pigmented bands.....1. *tenella*
Elytra marked with oblique bands of ramose pigment, often in the form of stripes along dorsal portions.....2
2. Elytra milky white, a broad brown band across posterior half of each elytron.....3
Elytra largely brownish.....3
3. Each elytron with a broad irregular whitish band in front of middle and slightly interrupted near suture by irregular pigmented lines.....3. *chenopodii*
Costal region of each elytron in basal half with a large well-defined yellowish triangular area that extends on to the clavus and lateral margin of pronotum.....4. *pulchella*

1. *Norvellina tenella* (Baker)

Thamnotettix tenellus Baker (1896b, p. 24).

Fig. 421. Length 3.0–3.5 mm. Varying in color from yellow to dark brown. Color markings indefinite, but dorsum often heavily infuscated. Vertex about one-fourth longer at middle than next to eyes. Easily distinguished from the other members of the genus by the unique genitalia. Female

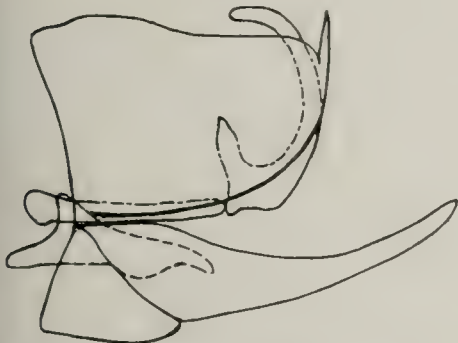


Fig. 420.—*Norvellina chenopodii*, male genitalia.

seventh sternite with posterior margin produced on median half, then narrowly, semi-circularly emarginate more than half way to base. Male plates short, broad, widest at apex, where they are roundedly truncate.

This is a widely distributed and an important economic species. Its occurrence in Illinois is both unusual and interesting.



Fig. 421.—*Norvellina tenella*.

Several years ago it was found on its native food plant, the sea purslane, *Sesuvium portuacastrum*, along the Atlantic Coast on sandy beaches, but as far as is known these beach plants are not found in Illinois. It has been taken in abundance from a planting of horse-radish in Illinois, where it caused a diseased condition similar to curly top of sugar beets.

Illinois Records.—COLLINSVILLE: on horse-radish, Oct. 6, 1936, K. J. Kadow, 58 ♂, 34 ♀; on horse-radish, July 14, 1938, L. H. Shropshire, 1 ♀.

2. *Norvellina seminuda* (Say)

Jassus seminudus Say (1831, p. 307).

Length 4.5–5.0 mm. Milky to creamy white, with a broad, brown saddle band on elytra. Vertex a little longer at middle than next to eyes. Scutellum often with irregular brownish markings. Elytra with the broad

brown saddle stripe across the posterior half of each clavus and narrowed to half that width on the costa; fourth apical cell often testaceous.

Female seventh sternite with posterior margin truncate or slightly produced, with a wedge-shaped median tooth, which is slightly notched at middle. Male plates long, triangular, apices narrowed, bluntly pointed.

This is one of our common conspicuously marked species, which frequently occurs on cultivated crops, although it apparently does not pass its life cycle upon them. It is found in the eastern states and in the Middle West.

Illinois Records.—Many males and females, taken May 7 to October 31, are from Algonquin, Alton, Alto Pass, Anna, Antioch, Beach, Bradley, Carman, Centerville, Champaign, Chicago, Clay City, Clayton, Collinsville, Danville, Decatur, Dixon, Dolson, Eichorn, Ernst, Evergreen Park, Fulton, Grafton, Grand Tower, Hamburg, Hanover, Hardin, Havana, Horseshoe Lake, Kampsville, Kankakee, Lima, Mahomet, Mason City, McHenry, Metropolis, Monmouth, Mount Carmel, Oak Lawn, Oquawka, Palos Park, Pike, Pulaski, Putnam, Quincy, Rosiclare, St. Anne, Savanna, Shawneetown, Urbana, Vienna, Volo, White Heath, White Pines Forest State Park, Wilmington, York, and Zion.

3. *Norvellina chenopodii* (Osborn)

Eutettix chenopodii Osborn (1923, p. 161).

Length 4.5–5.25 mm. Vertex a little longer at middle than next to eyes. Vertex, pronotum, and scutellum reddish brown, irrorate. Elytra milky white, with median saddle spot, a basal and an apical band on each elytron consisting of minute reddish-brown irrorations. Eyes reddish brown. Female seventh sternite usually slightly emarginate on either side of a broad short median tooth, which is notched at apex. Male plates, fig. 420, broad at bases, concavely rounded to elongate filamentous apices.

Distributed through the eastern states, the Middle West, and west to Utah, this is a common species on *Chenopodium*, on which it produces bright reddish spots by its feeding punctures. It frequently causes economic damage to spinach, swiss chard, and

beets, which belong to the same plant family as *Chenopodium*.

Illinois Records.—Males and females, taken May 18 to November 13, are from Algonquin, Alton, Anna, Antioch, Barry, Carbondale, Centralia, Champaign, Clay City, Cornfield, Decatur, Galena, Havana, Hillsboro, Kankakee, Keithsburg, Lawrenceville, Mason City, Monmouth, Monticello, Oak Lawn, Oakwood, Onarga, Oquawka, Palos Park, Pulaski, Putnam, Springfield, Urbana, Vienna, and Wilmington.

4. *Norvellina pulchella* (Baker)

Eutettix pulchellus Baker (1896b, p. 24).

Length 4.5 mm. Vertex only slightly longer at middle than next to eyes; testaceous brown, with an ivory line in front of the anterior depression into which extend four equidistant brown points. Pronotum with an ivory line on each lateral margin. Scutellum with three white spots, one on apex and one on each lateral margin. Elytron largely brownish except for a large yellowish triangular area, mostly in front of middle, which covers costal area and part of clavus; apical regions of elytra also with whitish areas but these irregular; three pairs of equidistant white spots on each clavus along suture. The female seventh sternite slightly rounded, median fourth slightly emarginate, with two minute teeth at apex extending slightly beyond margin. Male plates long, triangular, apices acute.

This beautifully marked species occurs in northern Illinois on *Eriogonum*.

Illinois Records.—GRAND DETOUR: Aug. 22, 1935, DeLong & Ross, 1 ♀. OAK LAWN: at light, summer 1934, DeLong & Ross, 1 ♂.

83. *REMADOSUS* Ball

Remadosus Ball (1929, p. 3).

Fig. 201. The genus is characterized by a very short and broad vertex, which is parallel margined, transverse, and broadly rounded to front. Ocelli situated in a slight depression distant from the eyes, distinctly below level of disc. Venation simple.

The three species of the genus are made up of large individuals that live in freshwater marshes on species of *Spartina*. Only one species is known to occur in Illinois.

1. *Remadosus magnus* (Osborn & Ball)

Athysanus magnus Osborn & Ball (1897, p. 225).

Length 7 mm. Vertex, fig. 201, short, almost parallel margined, four times as broad as long. Vertex, pronotum, and scutellum finely irrorate with fuscous, a transverse ivory band on pronotum. Elytra dark, nervures pale fuscous, with pale margins. Female seventh sternite, fig. 292C, with posterior margin triangularly notched at middle and with a rounded lobe on each side that is a little shorter than the produced lateral angles. Male genitalia as in figs. 292A, 292B.

This is a common inhabitant of the wet prairies of the Middle West and apparently feeds upon species of *Spartina*. It is reported from *Spartina michauxiana* in Iowa and Colorado, and in Florida it has been taken from the salt marsh, where it apparently feeds on *Spartina patens*.

Illinois Records.—AMBOY: Aug. 8, 1934, DeLong & Ross, 3 ♂. ANTIOCH: Aug. 27, 1932, Ross & Mohr, 1 ♀. EVERGREEN PARK: Aug. 23, 1934, DeLong & Ross, 2 ♀; July 1, 1935, DeLong & Ross, 2 ♂. OAK LAWN: July 27, 1934, DeLong & Ross, 1 ♀; in lamp globe, Aug. 22, 1934, DeLong & Ross, 3 ♂; July 1, 1935, DeLong & Ross, 1 ♂; Sept. 6, 1935, T. H. Frison, 1 ♀. OGDEN: July 17, 1928, H. H. Ross, 1 ♀. SUMMIT: July 17, 1935, DeLong & Ross, 2 ♀.

84. *TROPICANUS* DeLong

Tropicanus DeLong (1944a, p. 87).

Fig. 202. Very similar to *Paraphlepsius* but with very short lateral pronotal margins. Eyes appearing almost to touch bases of elytra. Vertex rounded to front. This genus is represented in the United States by a single species.

1. *Tropicanus costomaculatus*
(Van Duzee)

Allygus costomaculatus Van Duzee (1894b, p. 207).

Phlepsius pulchripennis Baker (1898a, p. 65).

Length 5 mm. Vertex angularly produced, a little longer at middle than next to eyes, slightly less than twice as wide as long; disc faintly marked with brown. Pronotum strongly produced anteriorly, nearly

truncate on posterior margin; faintly marked with brownish spots and small red dots, and with two darker spots behind each eye. Elytra largely hyaline, veins darker, and with three irregular longitudinal brownish areas on each clavus, one on disc of each elytron, and one on each costal vein. Seventh sternite of female produced at middle one-third into a rounded lobe, which is a little longer than the rounded lateral angles.

This species is known only from Texas.

85. *PARAPHLEPSIUS* Baker

Paraphlepsius Baker (1897, p. 158).

Figs. 422, 423, 427. Vertex as wide as or wider than pronotum, with margin thin, acutely angled with front, or rounded to front without a definite margin. Disc flat or sloping to front, without a transverse furrow. Elytra exceeding abdomen in length.

This is a large genus, of which 64 species have been recorded for the United States; 21 are known to occur in Illinois, and several others may be found here.

KEY TO SPECIES

- 1. Females.....2
Males.....27
- 2. Color patterns of elytra showing transverse banding, with paler and darker shades of brown, dark red or tawny...4
Color patterns of elytra without transverse banding.....3
- 3. Front margin of vertex well produced, foliaceous.....24
Front margin of head not strongly produced or foliaceous.....6
- 4. Seventh sternite definitely produced at middle, as in figs. 426B, 426X.....5
Seventh sternite, fig. 426A, shallowly and concavely excavated, with a short median U-shaped notch...1. *optatus*
- 5. Seventh sternite, fig. 426B, notched at apex of produced portion, forming two distinct pointed teeth.....
2. *tullahomi*
Seventh sternite, fig. 426X, convexly rounded on median third, without teeth.....3. *strobi*
- 6. Vertex, pronotum, and scutellum yellowish or tawny; elytra heavily marked with brown or black pigment.....7
Vertex, pronotum, and scutellum not definitely marked in contrast with elytra 10
- 7. Length 7.5 mm.; seventh sternite, fig. 426V, with a broad shallow notch at center.....4. *rossi*
Length not more than 6.0 mm.; median notch in seventh sternite narrow, as in fig. 426D.....8

8. Seventh sternite, fig. 426D, tapered apically, median portion produced with a median incision, forming two pointed appressed teeth.....**5. collitus**
 Seventh sternite not tapered apically, median portion notched, teeth not appressed, as in fig. 426F.....9

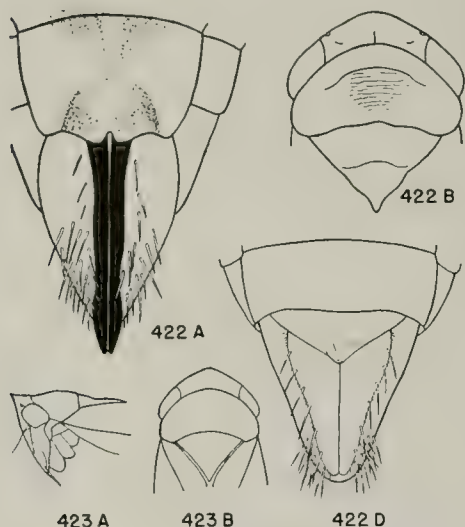


Fig. 422.—*Paraphlepsius umbrosus*. A, female genitalia; B, head and pronotum; D, male external genitalia.

Fig. 423.—*Paraphlepsius solidaginis*. A, lateral view of head and thorax; B, head and pronotum.

9. Length more than 5.5 mm.; elytra dark brown; median teeth of seventh sternite, fig. 426F, separated by V-shaped notch, margin of sternite broadly concave...**6. fulvidorsum**
 Length not exceeding 5.25 mm.; elytra darker, appearing almost black; median teeth of seventh sternite, fig. 426G, broad, short, and rounded, separated by shallow, U-shaped notch, margin slightly notched between these and lateral angles.....**7. eburneolus**
 10. Vertex rounded in front, or slightly angulate.....**11**
 Vertex distinctly angulate, definitely longer at middle than next to eyes.....**20**
 11. Vertex short, margins parallel, or vertex rounded to front, or both.....**12**
 Vertex slightly longer at middle than next to eyes, angled with front.....**15**
 12. Seventh sternite, fig. 426C, broadly, deeply, angularly excavated on posterior margin practically the full width of sternite.....**8. latifrons**
 Seventh sternite notched only at center, not broadly and deeply excavated....**13**
 13. Seventh sternite, fig. 426J, notched at center, producing two proximal short and sharp-pointed teeth....**9. tigrinus**

- Seventh sternite with a broader notch, without proximal apical teeth, as in figs. 426I, 426U.....**14**
 14. Median three-fourths of seventh sternite, fig. 426U, produced decidedly beyond the lateral angles, with a broad deep V-shaped notch at center, producing two rounded lobes.....**10. maculosus**
 Median portion of seventh sternite, fig. 426I, not produced beyond lateral angles, notched on either side of two median apically rounded teeth or narrow lobes, which are separated by a broadly angular and shallow median emargination.....**11. turpiculus**
 15. Pale gray, marked with definite black spots on vertex, scutellum, and pronotum; clavus and costa of each elytron usually with a narrow irregular band across middle.....**1. optatus**
 Darker, brown without definite black spots except where coloration of face is visible on margin of vertex.....**16**
 16. Length not exceeding 5 mm.; ovate in form, short and broad.....**17**
 Length 6 mm. or more.....**18**
 17. Seventh sternite, fig. 426L, deeply and concavely emarginate, with median incision forming two rounded black-bordered sunken lobes.....**12. altus**
 Seventh sternite, fig. 426H, broadly, very shallowly concave; margin of excavation truncate, with a median V-shaped notch.....**13. pusillus**
 18. Seventh sternite, fig. 426N, with lateral margins roundedly narrowed to median half, which is deeply, broadly and angularly notched.....**14. incisus**
 Seventh sternite with distinct lateral angles, posterior margin shallowly concave, as in figs. 426O, 426P.....**19**
 19. Lateral angles of seventh sternite, fig. 426O, rounded, rather narrowly, roundedly emarginate between these and a pair of rounded teeth formed by a median incision.....**15. umbrosus**
 Lateral angles of seventh sternite, fig. 426P, sharply angled, very shallowly emarginate on either side to a minute median V-shaped notch; margin without produced teeth or lobes.....**16. lascivius**
 20. Seventh sternite, fig. 426W, with lateral margins rounded to posterior margin, which is truncate and very faintly and concavely emarginate on median third.....**17. truncatus**
 Seventh sternite with prominent produced lateral angles, posterior margin notched or excavated.....**21**
 21. Seventh sternite, fig. 426T, with median third squarely excavated half way to base and bearing a basal tooth as wide as excavation and extending half way to posterior margin.....**18. irroratus**
 Seventh sternite broadly excavated from lateral angles, with a median notch or incision.....**22**
 22. Excavation of seventh sternite, fig. 426K, composed of shallow emarginations on either side of a pair of median rounded teeth.....**19. tennesse**

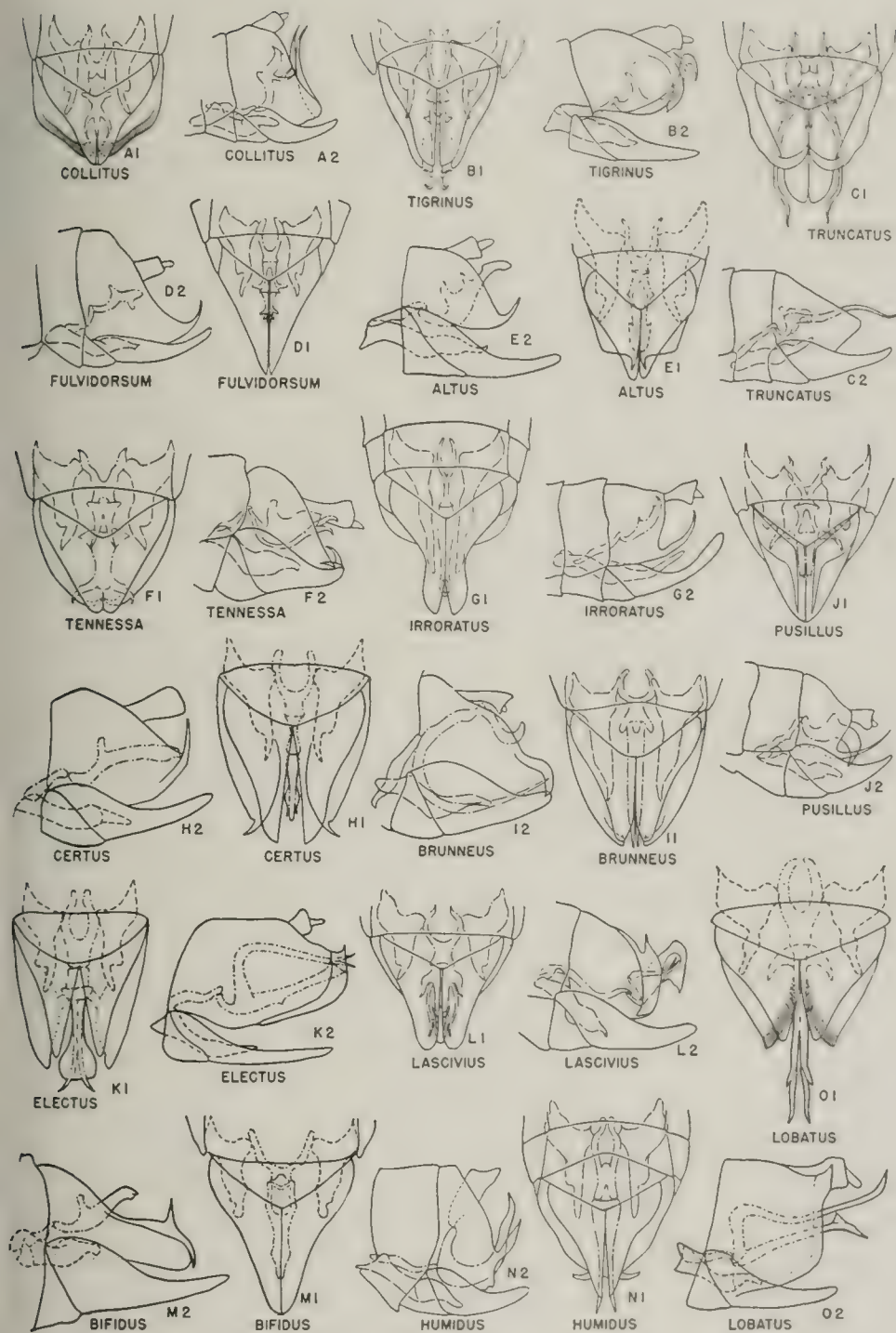


Fig. 424.—*Paraphlepsius*. A–O, male genitalia. 1, ventral aspect; 2, lateral aspect.

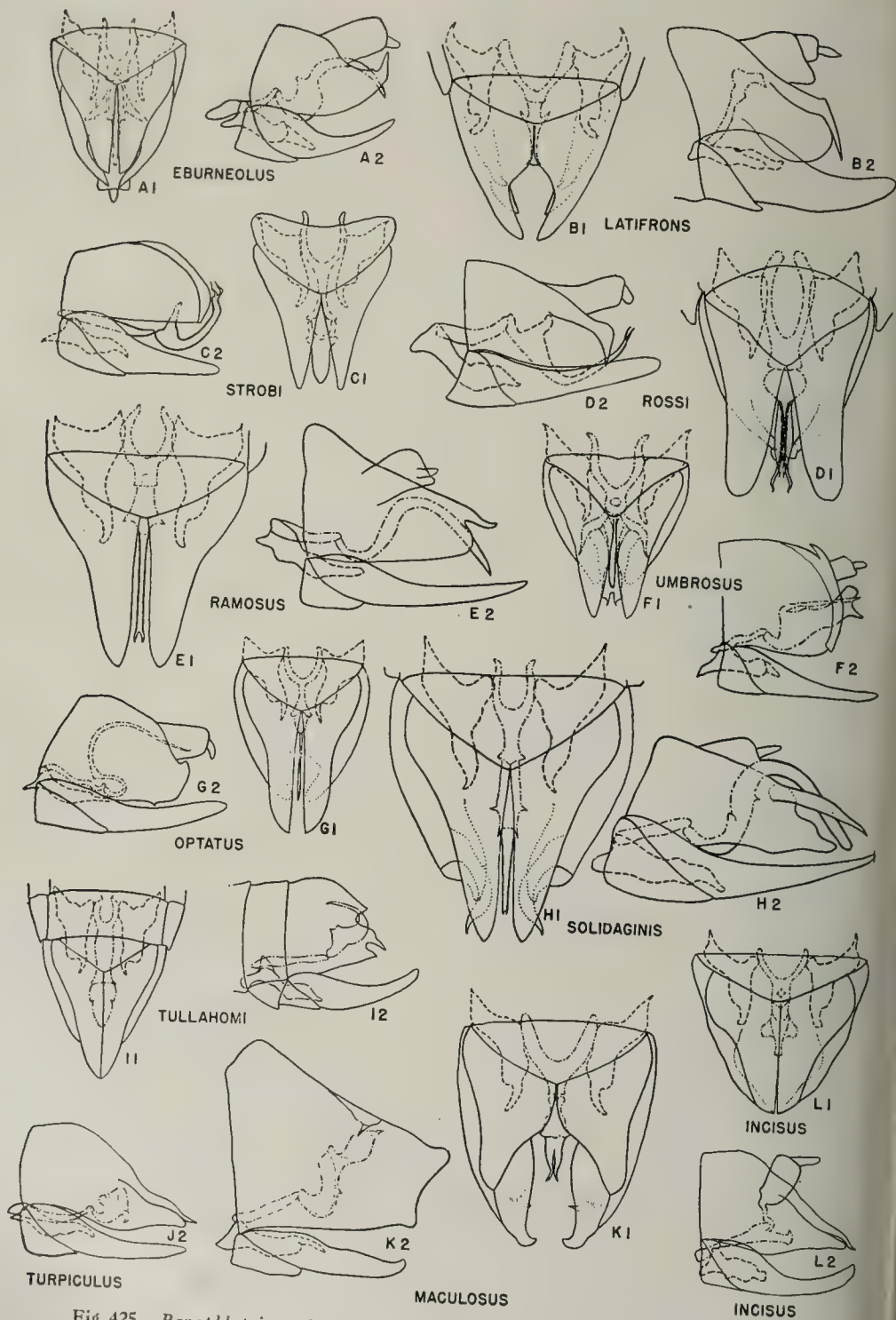


Fig. 425.—*Paraphlepsius*. A–L, male genitalia. 1, ventral aspect; 2, lateral aspect.

- Excavation deeper, squarely excavated from narrow pointed lateral angles... 23
23. Rounded median teeth, fig. 426K, separated by a narrow V-shaped median notch one-third the distance to base... 20. **brunneus**
- Rounded median teeth, fig. 426E, appressed, divided one-fifth the distance to base... 21. **lobatus**

- Color pattern of elytra without transverse banding... 28
28. Front margin of head well produced, foliaceous... 51
- Front margin of head not strongly produced or foliaceous... 31
29. Each pygofer, fig. 425I, notched on either side of a median spine on caudal margin... 2. **tullahomi**



Fig. 426.—*Paraphlepsius*. A-Y, female seventh sternite.

24. Seventh sternite, fig. 426Q, with a bifid tooth at middle, which is produced decidedly beyond lateral angles... 22. **humidus**
- Seventh sternite truncate, notched or excavated, not produced at center... 25
25. Seventh sternite broadly excavated or notched from lateral angles... 26
- Seventh sternite, fig. 426M, truncate posteriorly, incised next to lateral angles, notched at middle... 23. **ramosus**
26. Seventh sternite, fig. 426Y, broadly, angularly notched two-thirds the distance to base from pointed lateral angles... 24. **bifidus**
- Seventh sternite, fig. 426S, broadly, shallowly excavated less than one-fifth the distance to base; anterior margin of excavation truncate, slightly notched at middle... 25. **solidaginis**
27. Color pattern of elytra showing transverse banding, with paler and darker shades of brown, dark red, or tawny... 29

- Each pygofer rounded, not notched on caudal margin... 30
30. Aedeagus, fig. 425G, long, very slender, curved dorsally, then caudally to caudal margin of each pygofer... 1. **optatus**
- Aedeagus, fig. 425C, shorter, broad at base, narrowed to a pair of finger-like tips... 3. **strobi**
31. Vertex, pronotum, and scutellum yellowish or tawny; elytra heavily marked with brown or black pigment... 32
- Vertex, pronotum, and scutellum not definitely marked in color, in contrast to elytra... 35
32. Pygofers, fig. 425D, with dorsocaudal spines directed ventrally... 4. **rossi**
- Pygofers with ventrocaudal spines or without spines... 33
33. Aedeagus short, with short dorsal and ventral processes... 34
- Aedeagus, fig. 425I, long, slender, convexly curved upward, without dorsal or ventral processes... 7. **eburneolus**

34. Each pygofer, fig. 424D, oblique caudally, terminating in a ventral, upturned, spinelike apex; aedeagus with very short ventral and dorsal processes. **6. fulvidorsum**
Each pygofer, fig. 424I, more truncate caudally, with a long heavy dorsally directed spine on ventrocaudal margin; aedeagus with a pair of rather long spines on ventral side. **5. collitus**
35. Vertex rounded in front or slightly angulate. 36
Head distinctly angulate, vertex longer at middle than next to eyes. 46
36. Vertex short, margins parallel, or vertex rounded to front, or both. 37
Vertex slightly longer at middle than next to eyes, vertex angled with front. 40
37. Plates, fig. 425K, obliquely sloping on inner margins from bases so that they appear divergent. **10. maculosus**
Plates not obliquely sloping from bases on inner margins. 38
38. Vertex broadly rounded to front. 39
Vertex bluntly angled with front, margin usually thick; genitalia as in fig. 425J. **11. turpiculus**
39. Length not over 6 mm.; plates, fig. 424B, not concave on inner margins, inner margins straight, apices bluntly pointed. **9. tigrinus**
Length 7 mm. or more; plates, fig. 425B, concavely excavated on inner margins on apical halves, apices converging. **8. latifrons**
40. Aedeagus, fig. 425G, long, very slender, filamentous, curved dorsally and extending to caudal margins of pygofers, without processes. **1. optatus**
Aedeagus usually short and broad, or, if elongated, then broader and with dorsal or lateral processes. 41
41. Length not over 5.5 mm. 42
Length 6.0 mm. or more. 44
42. Aedeagus, fig. 424H, long, rather narrow, about the same width throughout, with a short erect dorsal process about one-third the distance from base. **26. certus**
Aedeagus not elongate, shorter and broader, wider at middle than at either end. 43
43. Each pygofer, fig. 424E, obliquely sloping to pointed apex, basal spine shorter; aedeagus with two dorsal toothlike processes and a blunt apex. **12. altus**
Each pygofer, fig. 424J, truncate caudally, basal spine long; aedeagus with one dorsal blunt tooth, apex curved ventrally, tapered, and pointed. **13. pusillus**
44. Dorsal margin of each pygofer, fig. 425L, obliquely sloping to bluntly pointed apex at ventral margin; a long dorsal spine resting on dorsal margin and extending caudally beyond apex. **14. incisus**
Dorsal margin of each pygofer not obliquely sloping to ventral margin, broadly rounded caudally, without long spine extending caudally. 45
45. Aedeagus, fig. 424L, abruptly and completely recurved ventrally and widened at apex; small dorsobasal processes extending into cavities formed by the recurved apex. **16. lascivius**
Aedeagus, fig. 425F, not recurved but straight, twice as long as broad, slightly narrowed before apex. **15. umbrosus**
46. Pygofers with spines arising from the ventrocaudal angles, as in fig. 424G. 47
Pygofer spines wanting or not arising on ventrocaudal margins. 48
47. Aedeagus, fig. 424G, simple in form, dorsal margin serrate; each pygofer appearing truncate caudally to basal spine. **18. irroratus**
Aedeagus, fig. 424F, broadly bifurcate at apex; each pygofer obliquely sloping from dorsal margin to ventrocaudal spines. **19. tennesa**
48. Each pygofer, fig. 424I, tapered to bluntly pointed apex, with a dorsal spine directed ventrally over apex. **20. brunneus**
Each pygofer without dorsal apical spine directed ventrally. 49
49. Aedeagus, fig. 424C, composed of a short basal dorsally enlarged portion, from which a pair of long slender divergent tapering processes extend beyond margins of pygofers. **17. truncatus**
Ventral and dorsal processes of aedeagus elongate, as in fig. 424K. 50
50. Pygofers, fig. 424O, short, greatly exceeded by aedeagus processes; dorsal process of aedeagus considerably longer than ventral process. **21. lobatus**
Pygofers, fig. 424K, longer; aedeagus processes of approximately equal length and scarcely exceeding caudal margins of pygofers. **27. electus**
51. Each pygofer, fig. 424N, shorter than basal width, with a ventrocaudal spine directed dorsally; aedeagus strongly, concavely curved upward. **22. humidus**
Each pygofer longer than basal width, spine dorso-caudal in position; aedeagus not curved concavely upward. 52
52. Aedeagus long, strongly curved in the form of an inverted sickle, as in fig. 425H. 53
Aedeagus, fig. 424M, short, five times as long as broad, almost straight, with a short dorsal process near middle. **24. bifidus**
53. Caudal margin of each pygofer, fig. 425E, notched, forming a short dorso-caudal spine. **23. ramosus**
Dorsal spine, fig. 425H, long, arising about one-third the distance from apex; dorso-caudal margin of each pygofer tapered to a bluntly pointed apex. **25. solidaginis**

1. *Paraphlepsius optatus* (Crumb)

Phlepsius optatus Crumb (1915, p. 194).

Length 5-6 mm. A species resembling *collitus* in general form and appearance but lighter in color. Vertex bluntly angled, a

little longer at middle than next to eyes and with margin thick and obtusely angled with front. Pale yellowish, with line on disc of vertex, two spots at base, a spot behind either eye on pronotum, two spots at apex, and two points on disc of scutellum black. Elytra white, sparsely inscribed; a black spot at middle and apex of each clavus, and black spots on costa; a faint irregular band across middle of clavus.

Female seventh sternite, fig. 426*A*, long, tapered, posterior margin very shallowly excavated; a short median U-shaped incision and a black marginal spot on either side. Male plates, fig. 425*G*, long, concavely narrowed at about half their length, then rather evenly produced to near apices, where they are convexly rounded to pointed apices on inner margins.

This species has erroneously been placed as a synonym of *cinereus* Van Duzee, but differs in external characters, and the aedeagus is entirely different. It is a common species on grasses at the margins of streams and in moist areas along the Illinois River in the willow-cottonwood habitat. It was recorded previously from Tennessee.

Illinois Records.—Many males and females, taken May 28 to October 2, are from Algonquin, Alton, Amboy, Barry, Cave in Rock, Danville, Duncans Mills, Fulton, Grafton, Hardin, Havana, Horseshoe Lake, Kampsville, Lima, Mahomet, Meredosia, Metropolis, Monticello, New Milford, Norris City, Oakwood, Olive Branch, Oregon, Pike, Quincy, Rock Island, Rosiclare, Springfield, Vienna, Wilmington, and Wolf Lake.

2. *Paraphlepsius tullahomi* (DeLong)

Phlepsius tullahomi DeLong (1916, p. 73).

Length 5.5–6.0 mm. Pale, with the posterior halves of elytra appearing banded. Vertex obtusely angled, one-fourth longer at middle than next to eyes, margin with a definite angle, acutely angled with front. Vertex, pronotum, and scutellum sparsely irrorate. Elytra sparsely marked on each anterior half, the posterior half densely marked with ramose pigment, a rather definite line on middle of clavus separating the two areas.

Female seventh sternite, fig. 426*B*, not narrowed apically, posterior margin slightly concave on either side of a median produced bifid tooth. Male plates, fig. 425*I*, long,

exceeding pygofer, concavely narrowed on either side about middle and produced to rather bluntly pointed apices.

This is apparently a pine species, occurring normally upon seedlings, and should be found in southern Illinois. It has been recorded from Alabama, Tennessee, and Ohio.

3. *Paraphlepsius strobi* (Fitch)

Bythoscopus strobi Fitch (1851, p. 58).

Phlepsius uhleri Van Duzee (1892*a*, p. 67).

Phlepsius franconianus Ball (1903, p. 228).

Length 4.5–5.0 mm. Small, generally brownish, with paler bands on elytra. Vertex bluntly angled, about one-half longer at middle than next to eyes, margin not sharp but rather definite, obtusely angled with front. Vertex fulvous, pronotum and scutellum brown. Elytra each with a white band across base from middle of scutellum to middle of clavus, a narrow band just beyond apex of clavus and a third just before apex of elytron.

Female seventh sternite, fig. 426*X*, with posterior margin slightly and roundedly produced on median third, a black spot on either side of middle, giving the appearance of a median tooth. Male plates, fig. 425*C*, long, gradually, slightly, and concavely narrowed to pointed apices.

This is one of the common pine species in the eastern United States and should be found in Illinois in the pine association.

4. *Paraphlepsius rossi* (DeLong)

Phlepsius rossi DeLong (1938*b*, p. 43).

Length 7.5 mm. Rather large, robust, with vertex, pronotum, and scutellum buff or dull yellow. Vertex bluntly angled, one-half longer at middle than next to eyes, margin of vertex angled with front. Vertex rather heavily irrorate with brown on margin at apex and on either side of middle. Pronotum irrorate on disc. Elytra heavily irrorate, appearing brown in contrast with the yellowish vertex, pronotum, and scutellum.

Female seventh sternite, fig. 426*I'*, with posterior margin produced and margined with brown on either side of a rather broad shallow V-shaped notch. Male plates, fig. 425*D*, long, gradually tapering to narrow blunt apices. Aedeagus in ventral view rather broad, apical half directed dorsally,

apex with four terminal slender processes; central pair long and forming the terminal portion of the aedeagus, the lateral pair short. A heavy spine-bearing process arising at the apex of each pygofer and extending across to opposite side.

This species occurs in Illinois and Connecticut in the floodplain woods association where tall grasses and dense herbaceous plants are found with cane in shaded areas. This is the only type of habitat in which it has been collected.

Illinois Record.—HEROD: Aug. 4, 1934, Mohr & DeLong, 1 ♂, 5 ♀.

5. *Paraphlepsius collitus* (Ball)

Phlepsius collitus Ball (1903, p. 227).

Length 5.5–6.0 mm. One of the smaller of the yellow-headed group. Vertex a little longer at middle than next to eyes, produced and bluntly angled, margin definite, vertex angled with front. Vertex, pronotum, and scutellum irrorate with pale or yellowish brown and contrasting with the dark brown irrorations on the elytra.

Female seventh sternite, fig. 426D, posteriorly emarginate on either side of a broad median tooth, which is bifid at apex. The entire margin heavily brownish. Male plates, fig. 424A, rather long, broad at bases, concavely narrowed on apical halves to bluntly pointed apices.

This is a common grass-feeding species in meadows and in open woodland habitats, and it occurs from Maine to Florida and west to Iowa. It is widely distributed in Illinois.

Illinois Records.—Males and females, taken May 6 to October 3, are from Anna, Billett, Carbondale, Champaign, Cobden, Dixon Springs, Dolson, Effingham, Eichorn, Fulton, Golconda, Grand Tower, Hamburg, Harrisburg, Havana, Herod, High Knob, Hillsboro, Karnak, Lima, Metropolis, Oakwood, Pike, Princeton, Putnam, Shawneetown, Thebes, Urbana, Ursa, and Vienna.

6. *Paraphlepsius fulvidorsum* (Fitch)

Jassus fulvidorsum Fitch (1851, p. 62).

Length 5.5–6.0 mm. Vertex, pronotum, and scutellum pale fulvous yellow, contrasting with the dark brown elytra. Vertex angulate, one-half longer at middle than next to eyes; margin sharp, acutely angled with front. Female seventh sternite, fig.

426F, with posterior margin incised at middle, forming a pair of median short blunt teeth; margin slightly emarginate between each tooth and lateral angles on each side. Male plates, fig. 424D, long, gradually narrowed from bases to pointed apices.

Although occurring in the eastern states and west to the Rocky Mountains, this species is not abundant but is taken more commonly in small numbers in habitats that are like the heath. It occurs on grasses in both moist and dry areas.

Illinois Records.—Males and females, taken July 8 to October 3, are from Anvil Rock, Apple River Canyon State Park, Channel Lake, Dixon Springs, Dolson, Elizabethtown, Fern Cliff, Grand Detour, Herod, Muncie, and Palos Park.

7. *Paraphlepsius eburneolus* (Osborn & Lathrop)

Phlepsius eburneolus Osborn & Lathrop (1923, p. 331).

Length 5.0–5.25 mm. Vertex light fulvous; pronotum, scutellum, and elytra dark brown. Vertex obtusely angled, one-third longer at middle than next to eyes, apex with a sharp edge, angled with front. Female seventh sternite, fig. 426G, with posterior margin notched at middle, produced, with a pair of blunt teeth; slightly emarginate on either side between each tooth and broadly rounded lateral angle. Male plates, fig. 425A, slightly concave on center of outer margins, each convexly rounded to inner margin at apex, forming a pointed apex.

Apparently this species is found on grasses in woodland areas only. It is apparently not abundant, although taken from Virginia to Minnesota. In Illinois, it has been taken from a woodland habitat.

Illinois Record.—DOLSON: July 24, 1936, DeLong & Mohr, 1 ♀.

8. *Paraphlepsius latifrons* (Van Duzee)

Phlepsius latifrons Van Duzee (1892a, p. 66).

Length 7 mm. Large, robust, with a short broadly rounded head. Vertex slightly longer at middle than next to eyes. Margin thick, obtusely angled, almost rounded to front. Pronotum almost four times as long as vertex. Color pale, heavily marked with brownish irrorations and ramose pigment lines.

Female seventh sternite, fig. 426C, broadly,

angularly excavated, the sides of excavation sinuate. Male plates, fig. 425B, concavely excavated on inner margins just below narrowed rather pointed and convergent apices.

This is a pasture species, recorded previously from the southeastern states, and has never been found abundantly. It occurs in pastures of long standing where there is a variety of herbaceous vegetation.

Illinois Records.—CAVE IN ROCK: Oct. 2, 1934, Frison & Ross, 1 ♀. CLAY CITY: at light, June 24, 1909, 1 ♂. DIXON SPRINGS: July 9, 1935, DeLong & Ross, 1 ♂, 1 ♀. GOLCONDA: June 22, 1934, Ross, Dozier, & Park, 1 ♀. SHAWNEETOWN: June 23, 1936, DeLong & Ross, 3 ♂, 3 ♀; June 27, 1936, DeLong & Mohr, 7 ♂, 1 ♀.

9. *Paraphlepsius tigrinus* (Ball)

Phlepsius tigrinus Ball (1909a, p. 80).

Length 6 mm. Tawny, brown, with faint reticulations, and with a pale spot on yellow scutellum. Vertex short, only slightly longer at middle than next to eyes, margin thick, not sharply angled with front. Female seventh sternite, fig. 426J, with the posterior margin short, roundedly emarginate on either side of a produced median tooth, which is narrowly bifid at middle. Male plates, fig. 424B, concavely narrowed on outer margins at middle, each produced and convexly rounded at apex to form pointed tips on inner margin.

Previously recorded from the District of Columbia and Ohio, this species has been taken in Illinois. It occurs only on pine.

Illinois Records.—GIBSONIA: Oct. 2, 1934, Frison & Ross, 1 ♂. OAKWOOD: Aug. 17, 1934, DeLong & Ross, 1 ♂.

10. *Paraphlepsius maculosus* (Osborn)

Phlepsius maculatus Osborn (1905a, p. 276).
Name preoccupied.

Phlepsius maculosus Osborn in Osborn & Lathrop (1923, p. 319). New name.

Fig. 427. Length 7 mm. Broad headed. Vertex short, scarcely longer at middle than next to eyes; margin thick, almost rounded to front. Pale, marked with brown irrorations that blend into spotted areas on head, pronotum, and elytra. Four dark spots on anterior margin of vertex and two darker spots next to the posterior border. Female seventh sternite, fig. 426U, long, median three-fourths produced abruptly into a lobe,

the median third of which is notched one-fourth the distance to base by a V-shaped notch with the apex rounded; black spot causes segment to appear more deeply notched. Male plates, fig. 425K, short, inner margins concavely excavated, forming divergent bluntly pointed apices. Pygofers greatly exceeding plates.

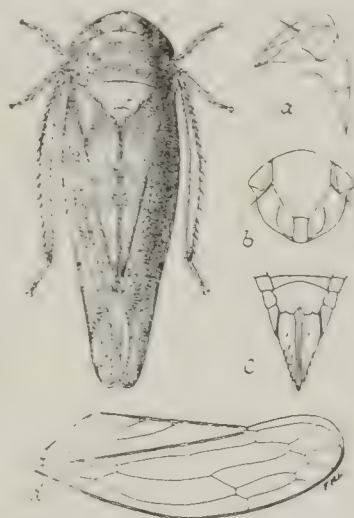


Fig. 427.—*Paraphlepsius maculosus*. Adult: a, profile; b, face; c, female genitalia; d, elytron. (From Osborn.)

This species, described from Ohio, is apparently rare or very difficult to capture. One male was collected in Illinois on a sand prairie that is being invaded by woodland. Records indicate that the species is usually taken in prairie habitats.

Illinois Record.—ST. ANNE: July 20, 1934, DeLong & Ross, 1 ♂.

11. *Paraphlepsius turpiculus* (Ball)

Phlepsius turpiculus Ball (1900b, p. 200).

Length 6–7 mm. Broad headed. Vertex almost parallel margined, but little longer at middle than next to eyes, margin roundedly angulate, bluntly angled with front. Color rather uniformly and evenly irrorate with brownish pigment. Female seventh sternite, fig. 426I, with posterior margin rather deeply and concavely excavated on either side of median half, which is broadly, shallowly, and angularly excavated, with a black mark at apex of excavation suggesting a deep incision. Male plates, fig. 425J, concavely narrowed and tapered to acute apices.

Each pygofer spine directed caudally, sinuate, and lying dorsad to caudal end of pygofer.

For many years we have referred specimens of this species to *fuscipennis*, which is a smaller and darker species and seems to be confined to the Atlantic coastal area; *turpiculus* is a prairie form closely related to *fuscipennis* and occurs in the northern part of Illinois, as well as other parts of the Middle West and the South. It occurs in moist habitats and in prairie lagoons in marshy areas.

Illinois Records.—BEACH: July 25, 1934, Frison & DeLong, 2 ♀. NORTHERN ILLINOIS: 1 ♀. OAK LAWN: Sept. 6, 1935, T. H. Frison, 1 ♂. ZION: Aug. 7, 1935, Ross & DeLong, 1 ♀.

12. *Paraphlepsius altus* (Osborn & Ball)

Phlepsius altus Osborn & Ball (1897, p. 228).

Length 5 mm. Short, robust. Vertex bluntly angulate, about one-fifth longer at middle than next to eyes, margin thick, bluntly angled with front. Rather evenly and densely irrorate with dark fuscous. Female seventh sternite, fig. 426L, with lateral angles strongly produced, between which the posterior margin is broadly, deeply, and abruptly emarginate, the margin of excavation at base forming a rounded black lobe on either side of a median narrow incision. Male plates, fig. 424E, long, slightly and concavely narrowed to acute bluntly pointed apices.

Recorded only from the Middle West, this species is common in the wet prairie and usually does not occur in dry prairie habitats. It has been collected in Illinois from short grasses in low moist prairie habitats.

Illinois Records.—FULTON: low pasture, July 8, 1934, DeLong & Ross, 1 ♂, 4 ♀. ZION: Aug. 7, 1935, DeLong & Ross, 1 ♀.

13. *Paraphlepsius pusillus* (Baker)

Phlepsius pusillus Baker (1892a, p. 66).

Phlepsius collinus Osborn & Lathrop (1923, p. 324).

Length 4.5–5.0 mm. Short, broad, robust. Vertex distinctly angulate, almost one-half longer at middle than next to eyes, margin distinct, angled with front. Vertex, pronotum, and scutellum dark, interspersed with white spots. Elytra marked with dark brown

vermiculate lines. Female seventh sternite, fig. 426H, short, posterior margin broadly, very shallowly emarginate, with a short V-shaped notch at middle; entire margin of excavation heavily embrowned. Male plates, fig. 424J, evenly, slightly, and convexly narrowed to bluntly angled apices.

Recorded previously from the Atlantic states, this is a common hillside pasture species in southern Illinois, where it occurs on short grasses. It seems to be rather definitely restricted to a dry upland habitat.

Illinois Records.—ANVIL ROCK: Oct. 3, 1934, Frison & Ross, 1 ♂, 3 ♀. CAVE IN ROCK: Oct. 2, 1934, Frison & Ross, 1 ♂. DIXON SPRINGS: July 29, 1934, DeLong & Mohr, 6 ♂, 2 ♀. FERN CLIFF: Aug. 3, 1934, DeLong & Mohr, 1 ♀. HEROD: Aug. 3, 1934, DeLong & Mohr, 1 ♂, 1 ♀. VIENNA: July 29, 1934, DeLong & Ross, 3 ♂, 7 ♀.

14. *Paraphlepsius incisus* (Van Duzee)

Phlepsius incisus Van Duzee (1892a, p. 73).

Length 6 mm. Rather broad, robust. Vertex bluntly angled, a little longer at middle than next to eyes, distinctly angled with front, margin definite. Marked with brown irrorations, often appearing whiter along the margin. Female seventh sternite, fig. 426N, with lateral margins sloping to median half of segment, which is rather deeply, broadly, and angularly excavated more than one-third the distance to base, and with a brown spot on either side of notch on outer sloping margin; lateral angles absent. Male plates, fig. 425L, deeply, concavely excavated on outer margins and produced to rather broad blunt rounded apices.

This is a grass-feeding species usually found in open woodland areas and often in rather densely shaded herbaceous growth. It is found in the East and Middle West, and occurs in small numbers in widely separated localities in Illinois.

Illinois Records.—ANTIOCH: July 5–7, 1932, T. H. Frison, 1 ♂. APPLE RIVER CANYON STATE PARK: Aug. 22, 1935, DeLong & Ross, 3 ♂. DOLSON: July 18, 1934, DeLong & Ross, 1 ♂, 1 ♀; July 24, 1936, DeLong & Mohr, 1 ♀. SAVANNA: July 19, 1892, McElfresh, Shiga, Forbes, & Hart, 1 ♀. URBANA: July 28, 1889, C. A. Hart, 1 ♀; Aug. 18, 1892, C. A. Hart, 1 ♀; Sept. 5, 1898, C. W. Woodworth, 1 ♀; July 18, 1917, 1 ♂; Aug. 17, 1920, 1 ♂.

15. *Paraphlepsius umbrosus* (Sanders & DeLong)

Phlepsius umbrosus Sanders & DeLong (1917, p. 88).

Length 6.0–6.5 mm. Large, rather robust, brownish. Vertex obtusely angled, one-half longer at middle than next to eyes, margin thick, obtusely angled with front; rather densely and evenly irrorate with brown, except for a paler spot each side next to eye. Female seventh sternite, fig. 426O, long, tapered, posterior angles prominent, narrowly rounded. Posterior margin produced, bifid at center, a rounded tooth either side; the margin slightly concave between each median tooth and lateral angle. Male plates, fig. 425F, long, rather narrow, slightly and concavely narrowed on outer margins to bluntly pointed apices. Aedeagus with a narrow straight dorsal process. Body of aedeagus not recurved but straight, a little narrowed before apex.

This species has a northern distribution and is an open woodland form living on herbaceous vegetation in rather definitely shaded areas. It has been taken in northern Illinois.

Illinois Record.—APPLE RIVER CANYON STATE PARK: July 11, 1934, DeLong & Ross, 1 ♀.

16. *Paraphlepsius lascivius* (Ball)

Phlepsius lascivius Ball (1900b, p. 200).

Phlepsius micronotatus Osborn & Lathrop (1923, p. 321).

Length 6 mm. Rather robust, brownish, with the black coloration of the face visible on margin of vertex from above. Vertex bluntly angled, slightly longer at middle than next to eyes, margin thick, obtusely angled with front; densely irrorate with dark brown except for a white spot at apex, on either side of which is a polished black spot formed by the extension of the black coloration on the upper portion of face. Female seventh sternite, fig. 426P, long, posterior margin broadly, very shallowly emarginate, with a slight notch at middle. Male plates, fig. 424L, concavely narrowed on median portion to broadly rounded apices.

This is a western prairie species and may eventually be found in the prairie habitat in Illinois.

17. *Paraphlepsius truncatus* (Van Duzee)

Phlepsius truncatus Van Duzee (1892a, p. 72).

Length 5.25–5.5 mm. Narrow, with bluntly angulate head; superficially resembling *irroratus* so closely that the two species cannot be separated except by use of the external genital characters. Vertex about one-fourth longer at middle than next to eyes and bluntly angled with front. Rather uniformly irrorate with brown. Female seventh sternite, fig. 426W, with lateral margins broadly rounded to posterior margin, which is almost truncate, but very slightly emarginate on median third, the emargination black bordered. Male plates, fig. 424G, gradually, slightly, and concavely narrowed to rather broad blunt apices, which are convexly rounded on outer margins to inner margins.

This is a very common and abundant species in the eastern states but is not found in as great numbers as *irroratus*. The optimum habitat seems to be a moist open woodland with dense herbaceous vegetation.

Illinois Records.—Many males and females, taken June 13 to October 3, are from Alsip, Alton, Anvil Rock, Barry, Cave in Rock, Dixon Springs, Dolson, Eichorn, Elizabethtown, Fairfield, Fulton, Gibsonia, Grand Tower, Herod, Hillsboro, Homer, Mahomet, Marshall, Metropolis, Mokenca, Muncie, Norris City, Oak Lawn, Pana, Princeton, Seymour, Shawneetown, Thebes, Urbana, Vienna, Volo, and Watson.

18. *Paraphlepsius irroratus* (Say)

Jassus irroratus Say (1831, p. 308).

Jassus testudinarius Burmeister (1838, pl. 14).

Length 5.5–6.0 mm. Slender, with a bluntly, angularly produced vertex that is about one-fourth longer at middle than next to eyes; margin rather thick, obtusely angled with front. Coloration somewhat variable, usually rather uniformly and heavily irrorate. Female seventh sternite, fig. 426T, truncate, with a short tooth produced on either side of median third, which is squarely and deeply excavated half way to base; a broad tooth the width of excavation extending half way to posterior margin. Male plates, fig. 424G, concavely narrowed near middle, apices produced as long narrow straplike processes that are blunt at apices.

Transcontinental in distribution, this is

the most common species of the genus and occurs in almost every habitat condition. It is common in pasture, meadow, and wet prairie situations, and occurs upon almost every type of cultivated crop.

Illinois Records.—Many males and females, taken May 15 to October 31, are from Adair, Algonquin, Alton, Anvil Rock, Apple River Canyon State Park, Arcola, Atlas, Aurora, Beach, Bradley, Buda, Bushnell, Cairo, Carbondale, Carman, Cave in Rock, Champaign, Charleston, Chemung, Chicago, Clayton, Clay City, Collinsville, Cornland, Danville, Decatur, Deland, Des Plaines, Dolson, Dongola, Dubois, Dwight, Eichorn, Elgin, Elizabethtown, Fairfield, Forrest, Fox Lake, Fulton, Galena, Geff, Gibson City, Gibsonia, Golconda, Grafton, Grand Detour, Grays Lake, Harrisburg, Havana, Herod, High Knob, Hillsboro, Kampsville, Kankakee, Karnak, Lima, Luther, Mahomet, Marshall, Meredosia, Metropolis, Momence, Monmouth, Monticello, Mount Carmel, Muncie, New Holland, Norris City, Oak Lawn, Oakwood, Ogden, Olive Branch, Onarga, Palos Park, Pana, Payson, Pécatonica, Pekin, Pike, Princeton, Pulaski, Putnam, Quincy, Rosiclare, Round Lake, St. Anne, Seymour, Shawneetown, Sheffield, Sibley, Sparta, Springfield, Starved Rock State Park, Sterling, Sumner, Thebes, Temple Hill, Urbana, Ursa, Vandalia, Vienna, Virginia, Volo, Waukegan, White Heath, and Zion.

19. *Paraphlepsius tennesa* (DeLong)

Phlepsius tennesa DeLong (1916, p. 75).

Phlepsius similis Lathrop (1917, p. 128).

Length 5.5–6.0 mm. Rather large and elongate. Vertex bluntly angled, about one-half longer at middle than next to eyes, forming a rather definite margin with the front. Marked with brownish irrorations, but without definite additional markings. Female seventh sternite, fig. 426R, with posterior margin rather broadly and shallowly emarginate on either side of a median narrowly notched portion; median line cephalad to notch and each emargination brown bordered. Male plates, fig. 424F, gradually, slightly, and concavely narrowed to blunt rounded apices.

This is a common grass-feeding species and is found abundantly in moist or partly shaded habitats. It was reported previously from Ohio and eastward.

Illinois Records.—Males and females, taken June 14 to October 2, are from Cache, Carmi, Cave in Rock, Dixon Springs, Dongola, Dolson, Elizabethtown, Fern Cliff, Jonesboro, Karnak, Norris City, Olive Branch, Shawneetown, Temple Hill, and Vienna.

20. *Paraphlepsius brunneus* (DeLong)

Phlepsius brunneus DeLong (1916, p. 74).

Length 6–7 mm. Resembling *tennessa* in form and size, but usually darker brown in color. Vertex obtusely angled, about one-half longer at middle than next to eyes, vertex definitely angled with front, margin rather sharp. Rather heavily and evenly irrorate with dark brown pigment. Female seventh sternite, fig. 426K, roundedly narrowed to produced narrow lateral angles, between which the posterior margin is broadly excavated about one-fourth the distance to base; posterior margin of excavation slightly produced at middle and rather deeply and narrowly notched, the concavity on each side of notch dark margined. Male plates, fig. 424I, rather long, concavely tapered to rather blunt pointed apices.

This species is found less commonly than *tennessa* but in similar moist grassy habitats. It was previously reported from Tennessee and the Lake Erie region.

Illinois Records.—Males and females, taken June 13 to August 17, are from Dolson, Eichorn, Havana, Herod, Karnak, Metropolis, Norris City, Quincy, St. Joseph, Shawneetown, and Vienna.

21. *Paraphlepsius lobatus* (Osborn)

Phlepsius lobatus Osborn (1898, p. 247).

Length 4.5–5.25 mm. Rather elongate, with a bluntly angled vertex, rounded at apex, and a little longer at middle than next to eyes; vertex bluntly angled with front, margin thick. Dorsum rather evenly, but not densely, irrorate with fuscous. Female seventh sternite, fig. 426E, slightly narrowed, lateral angles strongly produced and pointed, between which the posterior margin is abruptly excavated about one-fifth the distance to base, with the margin of excavation slightly and angularly produced and incised at middle. Male plates, fig. 424O, short, concavely narrowed to bluntly pointed apices, which are slightly divergent.

This is an uncommon Middle Western

species that has been collected in moist grassy habitats. It should occur in northern Illinois.

22. *Paraphlepsius humidus* (Van Duzee)

Phlepsius humidus Van Duzee (1892a, p. 76).
Phlepsius dentatus Baker (1898a, p. 65).

Length 6-7 mm. Large, broad, yellowish brown. Vertex obtusely angled, anterior margin thin, acutely angled with front; vertex and scutellum usually pale yellowish. Elytra with three indistinct transverse bands; a fuscous spot on suture at middle and apex of each clavus. Female seventh sternite, fig. 426Q, short, lateral angles rounded, between which the posterior margin is concavely notched on either side of the median half, which is produced beyond the lateral angles and is bifid at center, producing a pair of pointed teeth; sides of produced portion black margined. Male plates, fig. 424N, rather rapidly narrowed to acutely angled apices.

This species is abundant in the eastern half of the United States in fresh-water marshes and in moist or wet grassy meadow areas. Apparently it lives on coarse grasses or sedges.

Illinois Records.—Males and females, taken May 29 to October 5, are from Algonquin, Buda, Champaign, Channel Lake, Dubois, Grand Detour, Hamilton, Havana, Herod, Homer, Keithsburg, Lake Villa, Macomb, McHenry, Muncie, Oquawka, Princeton, Spring Valley, Sugar Grove, Sun Lake, Urbana, and Volo.

23. *Paraphlepsius ramosus* Baker

Paraphlepsius ramosus Baker (1897, p. 158).
Phlepsius tenuifrons Sanders & DeLong (1919, p. 235).

Length 7 mm. Large, robust, with a thin-margined almost foliaceous vertex, which is roundedly angulate; margin sometimes definitely upturned. Dark brown to fuscous, elytra with fuscous marking more dense posterior to middle, producing a banded appearance. Female seventh sternite, fig. 426M, long, appearing almost truncate, posterior margin slightly notched at middle, the margin between notches sinuate. Male plates, fig. 425E, long, concavely narrowed near middle on outer margins, then produced, forming bluntly pointed apices.

This northeastern species occurs on tall

grasses or sedges in fresh-water marshes, and on coarse grasses in low wet meadows. It has not been found on the prairies.

Illinois Records.—CHAMPAIGN: at light, July 27, 1887, C. A. Hart, 1 ♂. DOLSON: Rocky Branch, July 18, 1934, DeLong & Ross, 1 ♂, 1 ♀. MUNCIE: sweeping, July 25, 1908, 1 ♀; Aug. 15, 1917, 1 ♀. URBANA: sweeping, June 21, 1889, C. A. Hart, 1 ♂.

24. *Paraphlepsius bifidus* (Sanders & DeLong)

Phlepsius bifidus Sanders & DeLong (1917, p. 89).

Length 7 mm. Large, rather robust. Vertex roundedly angulate, about one-third longer at middle than next to eyes, flattened, margin acute, thin, sharpest at middle. Color dark gray, vertex yellowish, pronotum yellowish on anterior margin, disc darker. Scutellum ivory white, with sparse irrorations. Elytra marked with brown pigment, darker on posterior half, and with indication of a paler band at middle. Female seventh sternite, fig. 426Y, tapered to apex and sloping to prominent angles, between which the brownish posterior margin is deeply and angularly notched two-thirds the distance to base. Male plates, fig. 424M, long, broad at base, slightly and concavely narrowed near middle, and together produced to form a rather bluntly pointed apex. Pygofer with dorsal pointed processes.

This species has a northern distribution and is a woodland form. It may occur in northern Illinois.

25. *Paraphlepsius solidaginis* (Walker)

Acocephalus solidaginis Walker (1851a, p. 847).
Phlepsius nebulosus Van Duzee (1892a, p. 77).

Length 8 mm. This is probably the largest species of the genus. Vertex roundedly angulate, nearly twice as long at middle as next to eyes, margin sharp, acutely angled with front. Color grayish brown, the paler brown color often caused by the more sparse irrorations or ramose markings. Female seventh sternite, fig. 426S, tapered to apex, lateral angles produced and prominent, between which the posterior margin is broadly, decidedly emarginate; border of emargination practically truncate and slightly notched at middle, black margined. Male plates, fig. 425H, long, concavely narrowed near mid-

dle of outer margins, then produced to bluntly pointed apices.

This is a typical species of the moist prairie in the eastern states and west to Colorado. It is found also in meadows that are similar to the moist prairies.

Illinois Records.—BEACH: Aug. 22, 1906, 1♂. CHAMPAIGN: July 6, 1887, C. A. Hart, 1♀. FOX LAKE: Aug. 6, 1935, DeLong & Ross, 1♂. GALESBURG: 1♀. HOMER: at light, July 11, 1927, Frison & Glasgow, 1♀. PRINCETON: July 12, 1937, Mohr & Burks, 1♂. ZION: July 25, 1935, Frison & DeLong, 1♂, 1♀; Aug. 7, 1935, Ross & DeLong, 1♀.

26. *Paraphlepsius certus* (DeLong)

Phlepsius certus DeLong (1938b, p. 44).

Length 5.5 mm. Slender, brownish; in size, form, and color similar to *irroratus*, but differing in male genital structures. Vertex evenly marked with brown ramose pigment. Two darker spots on each elytron, one at end of claval suture and another about half way between this and apex of scutellum. Male plates, fig. 424H, long, slightly and concavely narrowed about half way to apices, which are bluntly pointed. Aedeagus in lateral view curved upward near base, then bifurcate, a short process extending dorsally, and a broad longer process directed caudally, the latter narrowed near apex. A long dorsally directed spine at the ventrocaudal margin of each pygofer. Female unknown.

This species has been collected only in a fresh-water marsh in Wisconsin.

27. *Paraphlepsius electus* (DeLong)

Phlepsius electus DeLong (1938b, p. 43).

Length 5 mm. In size and form similar to *irroratus*, but paler in color. Vertex bluntly angled, one-half longer at middle than next to eyes, margin rather thin, sharply angled with front. Vertex, pronotum, and scutellum cream colored, rather evenly irrorate with light brown. Elytra irrorate with darker brown.

Male plates, fig. 424K, about as long as combined width at base, gradually tapered to blunt apices. Aedeagus with a ventral and dorsal portion; ventral portion in lateral view narrow at base, strongly and abruptly broadened on apical third with a short dorsal process at apex; dorsal process curved

dorsally at base, then posteriorly, consisting of two lateral pieces that diverge at apex and exceed the ventral portion in length. Each pygofer with a short erect spine on dorsal apical margin.

This species is known only from Illinois and Missouri.

Illinois Record.—APPLE RIVER CANYON STATE PARK: July 11, 1934, Frison & DeLong, 1♂.

86. *TEXANANUS* Ball

Texananus Ball (1918, p. 384).

Head narrower than pronotum. Vertex bluntly angular, sometimes conical, vertex with margin rounded to front. Elytra broad and short.

About 30 species of this genus are recorded from the United States; six of them occur in Illinois. Several others may eventually be found here.

KEY TO SPECIES

1. Females.....2
Males.....7
2. Seventh sternite, fig. 428A, roundedly produced from base to apex, with two rounded teeth. Length 7.0–7.25 mm...**1. rufusculus**
Seventh sternite concavely rounded or notched.....3
3. Seventh sternite broadly and concavely excavated from lateral angles.....4
Seventh sternite with median half of posterior margin notched or excavated...5
4. Seventh sternite, fig. 428C, excavated half way to base, not exposing lateral margins of underlying membrane.....**2. superbus**
Seventh sternite, fig. 428B, deeply excavated two-thirds the distance to base, exposing lateral lobes of underlying segment at the sides.....**3. excultus**
5. Seventh sternite, fig. 428D, with posterior margin shallowly and angularly sloping to median narrow short V-shaped notch; entire insect tessellate...**4. areolatus**
Seventh sternite deeply notched at least half way to base; insect not tessellate...6
6. Seventh sternite, fig. 428E, notched more than half way to base, notch abruptly narrowed half of its way to base, apex rounded.....**5. decorus**
Seventh sternite, fig. 428F, with a broad V-shaped notch, and a narrow rather deep rounded emargination on margin on either side of notch...**6. cumulatus**
7. Plates broad, short, rounded, together almost semicircular in shape, as in fig. 428G.....8
Plates bluntly or rather sharply angled, as in fig. 428H.....9

8. Entire insect tessellate; each pygofer, fig. 428G, as broad as long, truncate caudally; aedeagus composed of one process.....**4. areolatus**
Insect brown, not tessellate; each pygofer, fig. 428J, more than twice as long as greatest width, concavely narrow to pointed caudal apex; aedeagus with a rounded dorsal process and a long straight ventral process...**2. superbus**
9. Reddish brown in color; length 7.0 mm. or more.....**1. rufusculus**
Usually darker brown in color; length less than 6.5 mm.....10
10. Plates, fig. 428H, triangular, together acutely pointed; aedeagus composed of one process.....**3. excultus**
Plates with apexes rounded, blunt; aedeagus with two processes, a long straight ventral process and a dorsal curved process.....11
11. Plates, fig. 428L, short and narrow; pygofer pointed caudally; dorsal process of aedeagus long and slender; elytra marked with pale lobate spots.....**5. decorus**
Plates, fig. 428I, longer and broader, pygofers blunt, rounded caudally; dorsal process of aedeagus short and broad; elytra brown, without lobate spots....**6. cumulatus**

1. *Texananus rufusculus* (Osborn & Lathrop)

Phlepsius rufusculus Osborn & Lathrop (1923, p. 340).

Length 7.0-7.25 mm. Large, robust, resembling *superbus* but larger and more reddish brown in color. Vertex one-fourth longer at middle than next to eyes, obtusely rounded to front; anterior border of vertex ivory yellow. Female seventh sternite, fig. 428A, broadly and roundedly produced from base to form a pair of short broadly rounded teeth separated by a narrow notch. Male plates, fig. 428K, rather long, triangular with bluntly pointed apexes. Aedeagus with a pair of ventral lateral processes, which are divergent, and a median process, which is enlarged at the base and abruptly tapered to a long slender process.

This uncommon species has been collected only in wooded floodplain areas, and its range of habitat is not known. It was previously recorded from Ohio and Missouri.

Illinois Record.—MAKANDA: March 27, 1935, Ross & Mohr, 1 ♀.

2. *Texananus superbus* (Van Duzee)

Phlepsius superbus Van Duzee (1892a, p. 81).

Length 6 mm. Broad, narrow headed, robust, rather heavily irrorate, dark fuscous.

Vertex roundedly angulate, about one-third longer at middle than next to eyes, rounding to front. Female seventh sternite, fig. 428C, broadly excavated half way to base; apex of emargination occupies about one-third of entire width between lateral angles and is truncate; side margins sinuate. Male plates, fig. 428J, short, broad, together semicircular. Aedeagus with a pair of long ventral processes that are abruptly narrowed on dorsal margin near apex and produced in narrow pointed apexes; dorsal process short, sickle shaped, with the curved apex directed dorsally and anteriorly. Each pygofer long, tapered, concavely narrowed on ventral margin to rather pointed apex.

This is a transcontinental grass-feeding species and occurs in meadows and pastures.

Illinois Records.—ANNA: Oct. 11, 1934, DeLong & Ross, 1 ♂. DIXON SPRINGS: July 29, 1934, DeLong & Ross, 16 ♂, 12 ♀; July 9, 1935, DeLong & Ross, 1 ♂.

3. *Texananus excultus* (Uhler)

Jassus excultus Uhler (1877, p. 467).

Length 6.0-6.5 mm. Broad, resembling *superbus* in general form and size, but the vertex, pronotum, and scutellum are tawny yellow in contrast to the darker brownish elytra. Commissural line of elytra with white lobate spots. Vertex about one-fourth longer at middle than next to eyes, rounded to front. Female seventh sternite, fig. 428B, broadly excavated two-thirds the distance to base; side margins slightly produced and rounded not far from the lateral margins; plates of underlying sternite exposed at sides of the excavation. Male plates, fig. 428I, broad, triangular, apexes bluntly pointed. Aedeagus with a basal dorsally produced process that is tapered and bluntly pointed; apical portion narrowed, tapered to a slender pointed apex, which is dorsally curved anteriorly, almost touching the basal portion. Pygofers short and pointed, not exceeding plates.

This species is southern in range, feeding on grasses in pastures and in wet areas and prairies.

Illinois Records.—CAVE IN ROCK: Oct. 2, 1934, Frison & Ross, 1 ♂, 1 ♀. FERN CLIFF: Aug. 3, 1934, DeLong & Mohr, 2 ♂, 3 ♀. GIBSONIA: Oct. 2, 1934, Frison & Ross, 20 ♂, 12 ♀. KARNAK: Aug. 8, 1934, Ross, DeLong, & Mohr, 1 ♀. MAKANDA: March 26, 1935, Ross & Mohr, 1 ♀. NORRIS CITY:

Oct. 1, 1934, Frison & Ross, 1 ♂. VIENNA:
June 29, 1934, DeLong & Ross, 8 ♀.

4. *Texananus areolatus* (Baker)

Phlepsius areolatus Baker (1898b, p. 30).

Length 6 mm. Ivory white, tessellate with brown, fuscous, and black. Vertex one-third longer at middle than next to eyes. Anterior margin sharp, with alternate ivory and black spots; front straight in profile. Irrorations of elytra often forming definite areolar spots. Female seventh sternite, fig. 428D, rather long; posterior margin broadly and shallowly emarginate, a short V-shaped

notch at apex, a brown spot on either side. Male plates, fig. 428G, short, broad, rounded, almost semicircular. Aedeagus composed of a structure that is enlarged dorsally near base and produced, bearing a narrowed anteriorly curved dorsal process; a long ventral process produced ventrally. Pygofers short, broadly truncate.

Recorded previously only from Kansas, this is a typical prairie species and apparently is restricted to the prairie habitat in Illinois.

Illinois Records.—CARMAN: July 29, 1936, Mohr & Burks, 2 ♂, 5 ♀; July 13, 1937, Mohr & Burks, 13 ♂, 10 ♀.

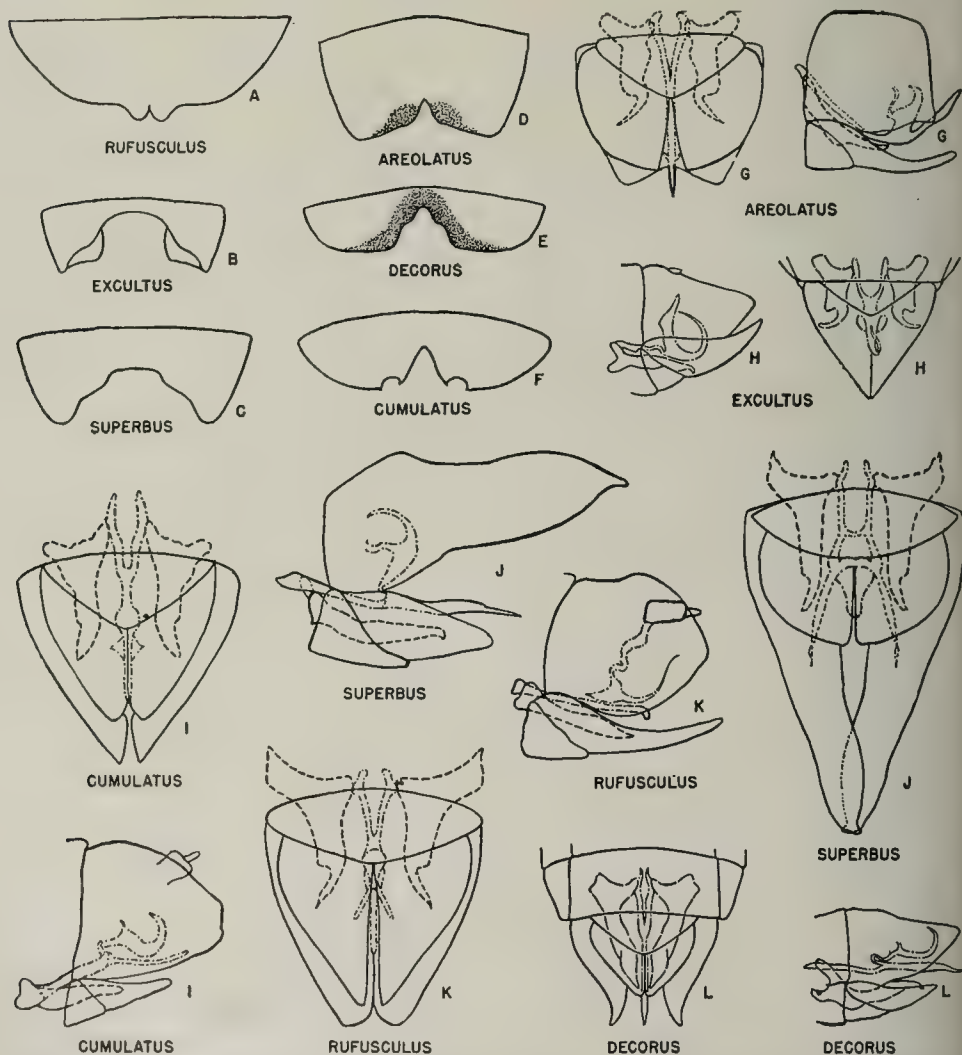


Fig. 428.—*Texananus*. A-F, female seventh sternite; G-L, male genitalia, ventral and lateral aspects.

5. *Texananus decorus* (Osborn & Ball)

Phlepsius decorus Osborn & Ball (1897, p. 230).

Length 6 mm. Rather short, robust, whitish, with flaring elytra. Vertex broadly, roundedly angulate, about one-third longer at middle than next to eyes; anterior margin bluntly angled. Vertex, pronotum, and cutellum marked with tawny; a transverse pale band on vertex extended forward to apex at middle. Elytral commissural line on clavus with ivory white lobate spots.

Female seventh sternite, fig. 428E, with lateral margins rounded to posterior margin, which is almost truncate; median fourth broadly, deeply, triangularly excavated two-thirds the distance to the base; sides of excavation sinuate. Male plates, fig. 428L, short and narrow, triangular apices roundedly angled. Aedeagus with a long slender bladeliike ventral process, and a rather long slender dorsal process with apical third curved dorsally. Pygofer each tapered to a bluntly pointed apex, these widely divergent and excavated laterally.

Throughout Illinois this is a rather common grass-feeding pasture species in moist habitats. It is also found on certain types of prairie. It occurs widely over the eastern United States.

Illinois Records.—Males and females, taken June 14 to October 20, are from Alton, Browns, Cairo, Cave in Rock, Cypress, Dubois, Duncans Mills, Elizabethtown, Farina, Fern Cliff, Gibsonia, Golconda, Grand Tower, Havana, Homer, Jonesboro, Marshall, Muncie, Shawneetown, Urbana, Vienna, and Watson.

6. *Texananus cumulatus* (Ball)

Phlepsius cumulatus Ball (1900b, p. 202).

Length 6.0–6.5 mm. Broadly oval, robust, reddish brown. Vertex short, scarcely longer at middle than next to eyes; faintly angulate, bluntly rounded to front. The brownish color is distinctly tinged with red. Female seventh sternite, fig. 428F, roundedly produced from base to a narrow rather shallow emargination on either side of a broad V-shaped notch, which extends half way to base. Male plates, fig. 428I, rather short, triangular, with bluntly pointed apices. Aedeagus with a rather long slender ventral process and a dorsal process that is rather broad at base, narrowed apically, and curved

dorsally. Pygofer short and with apices bluntly rounded.

As far as known, this species feeds only on the bearberry, *Arctostaphylos*, and is abundant upon that plant on the sandy areas along the shores of Lake Michigan. It is recorded only from the Middle West and Washington.

Illinois Records.—BEACH: Aug. 24, 1906, 1 ♂, 1 ♀; July 25, 1934, Frison & DeLong, 1 ♂, 1 ♀. ZION: July 25, 1934, Frison & DeLong, 74 ♂, 63 ♀; Aug. 7, 1935, Ross & DeLong, 7 ♂, 4 ♀.

87. *IOWANUS* Ball

Iowanus Ball (1918, p. 382).

The head is unusually narrowed, about three-fourths as wide as pronotum, and the anterior lateral margins of the pronotum slope strongly to the eyes. Individuals in the genus are large, 8–10 mm. in length, and the elytra are elongated. The male genitalia are distinct from those of *Texananus*. They can be recognized from the external view by rounded apical pygofer lobes, each of which is usually set off from the pygofer proper by a ventral and a dorsal notch. The female seventh sternite is almost truncate and with a narrow deep median incision.

The species of the genus are known to occur throughout the eastern half of the United States, in Texas, New Mexico, and as far south as the state of Guerrero in Mexico. They resemble each other very closely, but can be distinguished by the differences in genital structures. DeLong (1939b) records five species for the United States, and four of these have been taken in Illinois. The fifth species is known only from New Mexico.

KEY TO SPECIES

1. Females.....2
Males.....3
2. Female seventh sternite with median notch appearing U-shaped, extending halfway to base; teeth on each side of median notch long, slender.....3. *borrori*
Median notch narrowly V-shaped and teeth on each side of median notch blunt, fig. 429C.....
.....1. *majestus*, 4. *caducus*
3. Apex of each fork of ventral portion of aedeagus, fig. 431, bifid.....2. *dicentrus*
Apex of each fork of ventral portion of aedeagus pointed, as in fig. 430.....4

4. Ventral portion of aedeagus, fig. 430, bent sharply ventrally and produced apically for more than one-third its length.....

.....3. *borrori*

Ventral portion of the aedeagus with the apical portion not sharply bent ventrally, or, if bent, then apical portion very short.....5

5. Apical pygofer lobes, fig. 432, appearing short in lateral view, bent inwardly, not constricted basally; apical branches of ventral aedeagus slender, elongate, in lateral view appearing bent twice.....

.....4. *caducus*

Apical pygofer lobes, fig. 429, elongate, ovate, constricted at base; apical branches of ventral portion of aedeagus, short, thick, and curved ventrally.....

.....1. *majestus*

1. *Iowanus majestus* (Osborn & Ball)

Phlepsius majestus Osborn & Ball (1897, p. 229).

Length 9–10 mm. Large, broadheaded. Vertex about twice as wide as long, bluntly angled, yellowish, with two approximate dots near apex; a broad black band between anterior halves of eyes, with a straight margin in front, and emarginate on either side of the middle behind and often interrupted at middle.

Seventh sternite of female, fig. 429C, broad, lateral margins almost straight, posterior margin shallowly emarginate on either side of two large divergent acute teeth, which are produced beyond the lateral angles; between these teeth is a deep notch extending one-third the distance to base. Male pygofers, figs. 429A, 429B, each with elongate oval apical lobe, which is constricted at base. Ventral portion of aedeagus cleft at apex, forming two processes that are tapered and curved ventrally for a short distance at tip; dorsal portion of aedeagus with a long slender apical process that curves dorsally and extends almost to dorsal wall of joined pygofers; basal lobe shorter, pointed on caudal margin, and gradually broadened to base by the sloping anterior margin, which reaches base of dorsal portion; apical two-thirds of styles almost parallel margined, scarcely notched before outwardly bent blunt apices. Plates gradually narrowed to bluntly pointed apices.

This is a common species on herbaceous plants in shaded wooded areas. It is found in the East and Middle West.

Illinois Records.—WHITE HEATH: Nov. 13, 1937, J. C. Dirks, 1 ♀. WHITE

PINES FOREST STATE PARK: July 12, 1934, DeLong & Ross, 4 nymphs.

2. *Iowanus dicentrus* (DeLong)

Texananus dicentrus DeLong (1939b, p. 236).

Length 8.5 mm. Resembling *majestus* in general form, appearance, and coloration. Vertex bluntly, angularly produced, three-fifths as long at middle as width between eyes; a pair of conspicuous dark spots just above apex; transverse dark band between eyes interrupted at middle, forming a right angled triangular spot on either side, with the base along median line. Pronotum with dark median vermiculate markings just back of vertex.

Male plates, figs. 431A, 431B, long, narrowed to bluntly rounded apices. Pygofers shorter than plates, the caudal lobe of each pygofer elongate and narrow. Ventral portion of the aedeagus forked for about one-fourth of its length at apex, each branch conspicuously bifid at apex, bearing a prominent dorsal and a ventral tooth; dorsal portion of the aedeagus composed of a long slender process that curves caudally and then dorsally almost to the dorsal wall of the joined pygofers, also a shorter dorsal process arising at the base and tapered to a blunt apex. Female unknown.

This species is known only from one male, which was collected in Illinois.

Illinois Record.—FERN CLIFF: Aug. 3, 1934, Mohr & DeLong, 1 ♂.

3. *Iowanus borrori* (DeLong)

Texananus borrori DeLong (1939b, p. 237).

Length 9.5 mm. Resembling *majestus* in form and coloration but with bent terminal processes of aedeagus, which are more than one-third as long as basal portion; it also differs by having a long terminal lobe on each pygofer. Vertex broadly, bluntly produced, almost twice as wide between eyes as median length; dark spots on vertex above apex faint; transverse band between eyes dark, broad, interrupted at middle, and each portion broadened at both ends, the end next to either eye bifid. Pronotum with the darker markings on anterior half.

Female seventh sternite with prominent rounded lateral angles, between which the posterior margin is concavely rounded on either side of a rather long sharp-pointed

tooth produced on each side of a U-shaped notch, the notch extending half way to the base of sternite. Male plates, figs. 430*A*, 430*B*, long and slender, as long as pygofer. Each pygofer bearing a long rather broad caudal lobe; ventral portion of pygofer short and robust. The apical third of aedeagus bent abruptly ventrally, cleft, and forming two long apical widely separated spines; dorsal portion with a long slender curved process from which arises an elongate dorsal process at base.

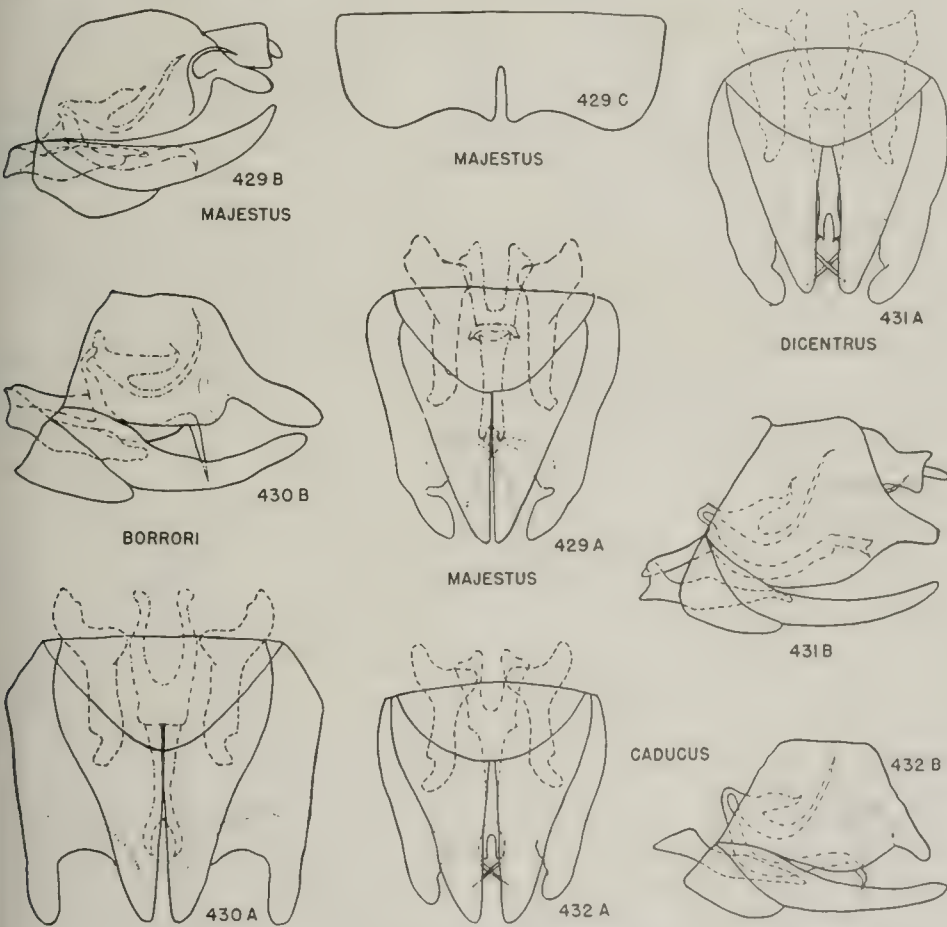
This species is known only from Illinois, Ohio, Wisconsin, and Minnesota. It occurs on rather shaded herbaceous growth in woodland areas.

Illinois Record.—WESTERN SPRINGS: Aug. 16, 1935, G. T. Riegel, 1 ♂.

4. *Iowanus caducus* (DeLong)

Texananus caducus DeLong (1939*b*, p. 238).

Length of male 8.0 mm.; female 9.0–9.5 mm. In form and coloration resembling *majestus* but with apical lobe of each pygofer short, blunt, and not indented dorsally or ventrally at base. Vertex broadly, bluntly produced, more than half as long at middle as basal width between the eyes; two small brown spots above apex; transverse band on disc decidedly interrupted at middle, forming a short band either side, the end next to each eye widely bifurcate, the middle portion narrowed, and the portion next to the middle line greatly enlarged caudally. Pronotum heavily infuscated on anterior margin.



Figs. 429–432.—*Iowanus*. *A*, ventral aspect of male genitalia; *B*, lateral aspect of male genitalia; *C*, female seventh sternite.

Female seventh sternite closely similar to that of *majestus* and having a slightly produced blunt tooth on either side of a rather narrow U-shaped notch reaching one-third the distance to the base. Male plates, figs. 432A, 432B, long, tapered to rather narrow rounded apices exceeding pygofer in length. Pygofer with very short rounded caudal lobes, which are not constricted or notched at base. Ventral portion of aedeagus long, apical fourth bent abruptly ventrally and cleft, forming two apical processes, which are each more slender than basal aedeagus body, and they are separated; dorsal portion of aedeagus with a long curved slender ventral process, from the base of which arises a short broader dorsal process.

Recorded from Oklahoma, Tennessee, and Illinois, this is a woodland species occurring on herbaceous vegetation. It is uncommon in Illinois.

Illinois Records.—HIGH KNOB: Oct. 3, 1934, Frison & Ross, 1 ♂. ANVIL ROCK: Oct. 3, 1934, 1 ♂, 2 ♀, Frison & Ross. HAVANA: Nov. 8, 1912, 1 ♀; Aug. 8, 1934, Frison & Mohr, 2 ♂, 1 ♀. FERN CLIFF: Aug. 3, 1934, Frison, Ross, Mohr, & DeLong, 1 ♂.

88. *FIEBERIELLA* Signoret

Fieberiella Signoret (1880, p. 67).

Figs. 223, 239D. Broad, robust, vertex flat, more than one-half again as wide between eyes as median length; anterior margin sharp, acutely angled with front. Face almost as broad as long. Elytra broad, opaque, flaring at tip.

This genus contains a single North American species, apparently imported from Europe.

1. *Fieberiella florii* (Stål)

Selenocephalus florii Stål (1864, p. 67).

Phlepsius atropunctatus DeLong (1923, p. 131).

Length 7.0–7.2 mm. Dull yellowish, densely irrorate with minute round black spots. Face with two heavy black bands sometimes fused just below vertex margin. Female venter milky white, seventh sternite and pygofer brownish, marked with black spots. Vertex flat, one-half to two-thirds wider between eyes than median length, a little shorter than pronotum, anterior edge sharp.

Female seventh sternite three and one-

half times the length of preceding; side margins strongly curved, covering lateral plates; lateral angles rounded and prominent; posterior margin sinuately concave, with a central shallow notch. Male plates, fig. 243, longer than combined width at base, rather broad, gradually narrowed two-thirds their length, then suddenly constricted and produced; plates greatly exceeded by pygofer, which are keeled at middle.

Known from Connecticut and Illinois, this is a rather common species on shrubs and has been taken from ornamental plantings on the University of Illinois campus, at private homes, and in park areas.

Illinois Records.—ALTON: July 27, 1934, DeLong & Ross, 1 ♂. URBANA: Aug. 8, 1932, 1 ♀; July 29, 1934, T. H. Frison, 4 ♀; Aug. 12, 1934, T. H. Frison, 1 ♂, 2 ♀; Aug. 16, 1934, DeLong & Ross, 1 ♂; Sept. 16, 1935, DeLong & Ross, 1 ♀.

89. *ACINOPTERUS* Van Duzee

Acinopterus Van Duzee (1892d, p. 307).

Fig. 212. Head narrower than pronotum, somewhat produced. Pronotum broad and rather short, anterior edge arcuate, sides long. Each elytron narrow, without appendix, apex sharply angled; nervures strong.

Beamer & Lawson (1938) record 26 species and varieties for the United States. All are western in distribution, but one species, *acuminatus*, is also found in the East. It occurs in Illinois.

1. *Acinopterus acuminatus* Van Duzee

Acinopterus acuminatus Van Duzee (1892d, p. 308).

Length 5.0–6.5 mm. Varying in color from dull brown to green or yellow, with a sharp-pointed apex at each elytron. Head pale, pronotum variable, usually darker. Elytra fulvous, apex of each dark, nervures pale, often with disc of costa and discal areoles of corium whitish, hyaline; claval suture brown. Vertex short, convex. Female seventh sternite moderately long, posterior margin with a shallow median notch, lateral lobes broadly rounded. Male plates long and narrow, pygofer twice length of plates.

Transcontinental in distribution, this is a very abundant species on grasses and herbaceous plants in pastures, meadows, and wooded areas.

Illinois Records.—Many males and females, taken June 5 to September 27, are from Anvil Rock, Cave in Rock, Danville, Dixon Springs, Dubois, Eichorn, Elizabethtown, Equality, Fairfield, Golconda, Grand Tower, Hardin, Havana, Karnak, Keithsburg, La Rue, Marshall, Meredosia, Monticello, Muncie, Oquawka, Pike, Ripley, Rosiclare, St. Anne, Shawneetown, Ursa, Vienna, and White Heath.

90. *BANDARA* Ball

Bandara Ball (1931a, p. 93).

Vertex almost flat, wider than long, margins nearly parallel, anterior margin thick and unusually accentuated by markings above and below; vertex definitely angled

with front. There is sometimes a second cross nervure between the sectors of the elytra.

Six species are included in this genus by Knull (1946); five of them occurring east of the Great Plains region, and the sixth, *animana* (Ball), is known only from Colorado. Two are known from Illinois and the three additional eastern ones may be looked for in future collecting.

KEY TO SPECIES

1. Elytra unicolorous, without spots.....
2. Elytra with round or oval pale spots....2
3. Males.....3
4. Females.....6
5. Aedeagus having a large preapical dorsal process, partly membranous, both proc-

5. *aurata*

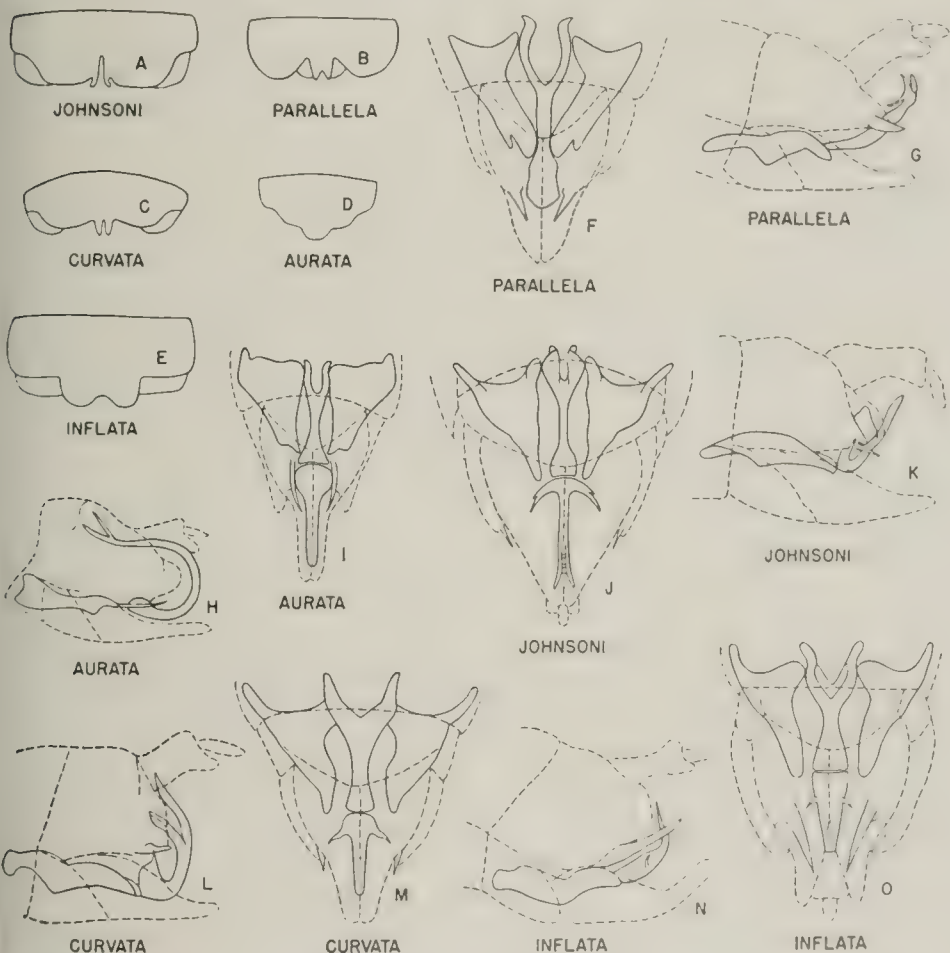


Fig. 433.—*Bandara*: A-E, female seventh sternite; F-O, ventral and lateral views of male genitalia. (Adapted from Knull.)

- ess and apex broad, the latter cleft at tip, fig. 433M.....2. **curvata**
Aedeagus having small processes or none at apex, fig. 433J.....4
4. Base of aedeagus with long lateral processes, fig. 433J; pygofer process slender and minute.....1. **johnsoni**
Base of aedeagus with short lateral processes, fig. 433O, or none; pygofer process stout.....5
5. Tip of aedeagus straight and simple; pygofer process nearly as long as apical segment of aedeagus, fig. 433O.....3. **inflata**
Tip of aedeagus curved, subdivided into small processes; pygofer process short, less than a fourth as long as apical segment of aedeagus, fig. 433F.....4. **parallela**
6. Apex of seventh sternite having a pair of small, finger-like lobes, figs. 433A and 433C.....7
Apex of seventh sternite having broad lobes or only a shallow emargination, figs. 433B and 433E.....8
7. Apical "fingers" of seventh sternite separated by an incision over twice as deep as the length of the finger, fig. 433A.....1. **johnsoni**
Mesal incision of seventh sternite no deeper than length of "fingers," fig. 433C.....2. **curvata**
8. Seventh sternite having a broad, emarginate mesal process, fig. 433E.....3. **inflata**
Seventh sternite having a narrow, emarginate mesal process, fig. 433B.....4. **parallela**

1. *Bandara johnsoni* (Van Duzee)

Eutettix johnsoni Van Duzee (1894a, p. 137).

Length 4.8–5.2 mm. Orange yellow, with six black dashes above margin of vertex and an interrupted line beneath; posterior margin of vertex, three stripes on pronotum, and numerous oval spots on the elytra milky white. Corium without supernumerary veinlets. Female seventh sternite, fig. 433A, narrowed at half its length and produced to a roundedly emarginate posterior margin, which is rather deeply, narrowly incised at middle to a slightly produced tooth on either side of incision on posterior margin. Male plates, fig. 433J, convexly narrowed to bluntly pointed produced apices. Aedeagus in ventral view, fig. 433J, curved at base, forming a spine on each outer margin; shaft bifid at apex. In lateral view, fig. 433K, a broad dorsal projection arises near middle and extends back even with base. Styles broad at base, short, tapered to slender pointed apices.

This species occurs in the eastern states and is known to extend as far west as

Ohio. It may be found in Illinois with additional collecting.

2. *Bandara curvata* Knull

Bandara curvata Knull (1946, p. 260).

Length 4.5–5.0 mm. Resembling *johnsoni* in general appearance and color pattern. A dark line just beneath vertex margin and six dark spots just above. Pronotum with three longitudinal white vittae, and elytra with white areolar spots as in *johnsoni*. Female seventh sternite, fig. 433C, rounded on lateral angles; posterior margin slightly emarginate, a pair of short proximal teeth at middle. Male plates tapered to blunt rounded apices. Styles rather long, apices narrow, blunt. Aedeagus, fig. 433M, broad at base; in lateral view, fig. 433L, it extends dorsally and curves anteriorly, apex bifid with the two portions usually appressed; a process arises at about the middle on the dorsoanterior margin and curves dorsally and anteriorly.

This species occurs on herbaceous or shrubby vegetation in open woodland in the eastern United States and west to Iowa.

Illinois Records.—APPLE RIVER CANYON STATE PARK: July 11, 1934, DeLong & Ross, 1 ♀. DONGOLA: Aug. 23, 1916, 1 ♀. DUBOIS: Aug. 8–9, 1917, 3 ♀. ST. JOSEPH: July 30, 1934, T. H. Frison, Jr., 1 ♀. SHAWNEETOWN: June 27, 1936, DeLong & Mohr, 1 ♀. URBANA: Aug. 9, 1920, J. R. Malloch, 1 ♂. VIENNA: June 14, 1934, DeLong & Ross 2 ♂, 1 ♀.

3. *Bandara inflata* Knull

Bandara inflata Knull (1946, p. 262).

Length 5.0–5.5 mm. In general appearance and color pattern resembling *johnsoni* but usually more orange in color. Female seventh sternite, fig. 433E, short, truncate, median third abruptly produced, forming a broad lobe which is broadly, shallowly indented at middle. Male styles, fig. 433O, narrowed at apices, blunt and divergent, gradually narrowed from bases to rather broad blunt rounded apices. Aedeagus, fig. 433N, curved dorsally, apex divided, forming two divergent attenuate spines; a pair of short spines arise near base on lateral margins.

This species has been recorded from Ohio and North Carolina, and may eventually be found in Illinois.

4. *Bandara parallela* Knull

Bandara parallela Knull (1946, p. 263).

Length 4.2–5.0 mm. Resembling *curvata* in general form, color, and appearance, but usually darker in color. Female seventh sternite, fig. 433B, with rounded lobelike lateral angles between which the posterior margin is broadly, rather deeply emarginate, with a broad short spatulate process at its apex; process slightly notched at apex and produced to same length as lateral angles. Male plates, fig. 433F, long, convexly rounded to blunt appressed apices. Styles elongate, with broad blunt rounded apices. Aedeagus, fig. 433G, curved dorsally, with two pairs of lateral processes arising near apex.

This is a common species in the eastern United States.

Illinois Records.—DIXON SPRINGS: June 24, 1936, DeLong & Ross, 1 ♀. ULLIN: May 26, 1932, H. L. Dozier, 1 ♀.

5. *Bandara aurata* (Ball)

Eutettix aurata Ball (1909a, p. 81).

Length 4.0–4.5 mm. Small, golden yellow or slightly darker, with a pair of narrow black lines along margin of vertex. Elytra golden, subhyaline, without white spots. Female seventh sternite, fig. 433D, narrow on lateral margins, posterior margin angularly produced to a blunt apex. Male plates, fig. 433I, long, slender on apical halves, apices narrow, appressed. Styles short, broad at bases, sloping to broad apices, which are pointed on inner margins. Aedeagus, fig. 433H, narrow, curved dorsally, then anteriorly beyond the base, apex divided into two long divergent processes.

This species is associated with pine in the Ohio River valley and the eastern portion of the United States. In Illinois we have not found this species on native pines but there is a possibility that it may become established in the extensive areas of pines that are being planted in the reforestation and national forest projects.

91. *EUTETTIX* Van Duzee

Eutettix Van Duzee (1892d, p. 307).

Head short, slightly conical, transversely depressed, slightly sloping. Elytra moderately long, usually slightly flaring. Venation simple, one cross nervure between the sec-

tors; elytra without supernumerary veinlets, or ramose lines, and without pigment bands.

The species of this genus are mostly shrub feeders and occur on oak and probably other shrubby growth, chiefly in the western states. Hepner (1942) records 38 species for the United States, 7 of which occur in Illinois.

KEY TO SPECIES

1. Elytra usually dark in color, if light with a paler spot near apex of clavus; color pattern usually evident. 2
Elytra light, white to fulvous, usually about the same throughout, without a light spot near apex of clavus. 6
2. Pronotum with a distinct dark band near posterior margin. 3
Pronotum without a distinct dark band near posterior margin. 5
3. Elytra semihyaline, fulvous, sometimes slightly clouded along margin of clavus. 1. *tristis*
Elytra not fulvous semihyaline, either opaque or spotted with opaque areas. 4
4. Male 5.5 mm. or more in length, female at least 7.0 mm. in length; vertex and scutellum usually orange; ventral fork of each pygofer hook, fig. 434B, greatly widened on outer half. 2. *pediculus*
Male and female less than 5.5 mm. and 7.0 mm., respectively; vertex and scutellum white to yellow; ventral fork of each pygofer hook, fig. 434C, not greatly thickened on outer half. 3. *pictus*
5. Scutellum pale, with dark basal angles; pygofer hooks, fig. 434D, bifid. 4. *luridus*
Scutellum darker, orange to fulvous, basal angles unicolorous; pygofer hooks, fig. 434E, not bifid. 5. *marmoratus*
6. Male more than 5.0 mm. in length, and female more than 5.5 mm. in length; ventral fork of each pygofer hook, fig. 434A, about as wide as dorsal forks. 6. *variabilis*
Male and female less than 5.0 mm. and 5.5 mm. in length, respectively; ventral fork of each pygofer hook, fig. 434F, much narrower than dorsal forks. 7. *quercii*

1. *Eutettix tristis* Ball

Eutettix subaenea var. *tristis* Ball (1907, p. 34).

Length of male 5.5 mm.; female 6.5 mm. Resembling *pictus* in general color, but paler and with dorsal fork of each pygofer hook extending as far as ventral fork. Vertex more than twice as wide as length at middle, almost parallel margined, transverse furrow shallow; vertex yellow, with two

large dark spots along anterior margin usually separated by a narrow yellow line, and with a wide dark band covering most of posterior half. Scutellum yellow; elytra semihyaline fulvous, with paler spots at apex of each clavus. Frons yellow, with two large black basal spots.

Female seventh sternite with posterior margin almost straight on either side of a

tex, pronotum, scutellum, and frons yellow, with dark markings, which include a spot on disc of frons; two large spots, each enclosing an ocellus, covering anterior half of vertex and basal portion of frons; spots separated at middle by a narrow light line; a broad band across posterior half of pronotum.

Female seventh sternite with the posterior

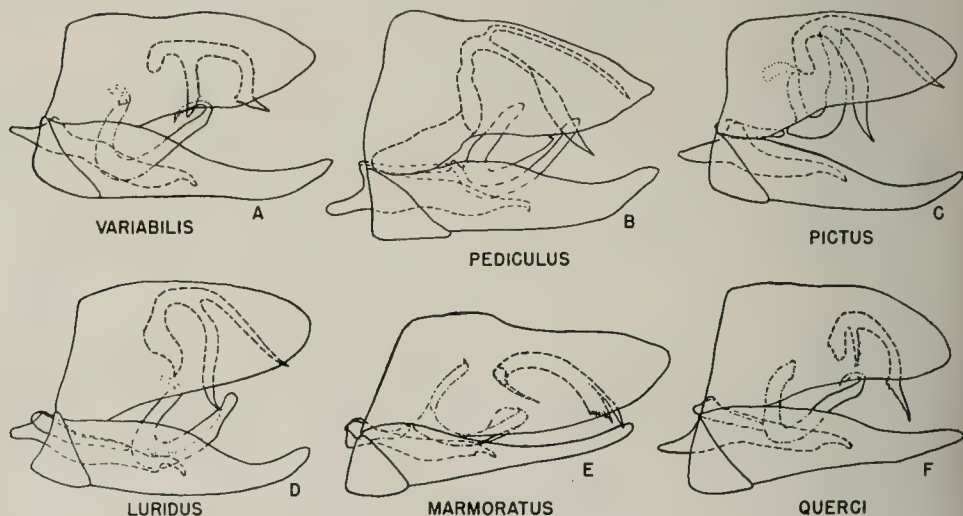


Fig. 434.—*Eutettix*. A–F, male genitalia.

produced median lobe. Each male pygofer hook bifid, bent near base, widest near middle, apex pointed; ventral fork widest near base, extending about as far as dorsal fork, pointed at apex; aedeagus almost parallel margined to outer third, narrowing to a bluntly pointed apex, which bears a pair of short processes on dorsal margin.

Recorded previously from the eastern states, this species has been taken in Illinois.

Illinois Records.—ALTON: June 26, 1934, DeLong & Ross, 1 ♂. ASHLEY: Aug. 7, 1917, 1 ♀. DUBOIS: Aug. 8–10, 1917, 4 ♀. GRAFTON: along river, June 26, 1934, DeLong & Ross, 1 ♀. MEREDOSIA: Aug. 19, 1917, 1 ♀.

2. *Eutettix pediculus* Hepner

Eutettix pediculus Hepner (1942, p. 273).

Length of male 5.75 mm.; female 7.0 mm. Resembling *pictus* in general appearance but larger and with distinctive male genitalia. Vertex about twice as wide between eyes at base as median length, almost parallel margined, transverse furrow shallow. Ver-

margin almost straight on either side of a prominent median lobe. Male pygofer hooks, fig. 434B, bifid, dorsal fork curved abruptly near base, almost parallel margined to pointed apex; ventral fork narrowest on basal third, much broader near middle, pointed at apex. Aedeagus almost parallel margined on basal three-fifths, gradually narrowing to a rounded apex, which bears a pair of short processes on dorsal margin.

This species is known to occur in some of the eastern states and in the Middle West.

Illinois Records.—ELIZABETHTOWN: July 8, 1935, Ross & DeLong, 1 specimen. ROSICLARE: July 5, 1935, Frison & Mohr, 1 specimen. ST. ANNE: Aug. 4, 1936, Frison & Burks, 1 ♂. THEBES: July 11, 1935, DeLong & Ross, 2 specimens.

3. *Eutettix pictus* Van Duzee

Eutettix pictus Van Duzee (1892c, p. 301).
Eutettix magnus Osborn (1900c, p. 395).

Length 5–6 mm. Elytra dark brown to black, each with a yellow spot. Vertex,

pronotum, and scutellum yellow. Anterior half of vertex and posterior half of pronotum black. Elytra shiny black; usually a commissural spot on each clavus anterior to apex, and the anterior two-thirds of costal margin pale yellow; spots often lacking in dark male specimens. Face black, with a broad yellow band beneath eyes. Female seventh sternite with the posterior margin broadly and concavely excavated, with a median short blunt tooth. Each male pygofer hook, fig. 434C, bifid, with ventral fork broader than and slightly longer than dorsal fork, bent near base, gradually broadened to outer third, apex pointed. Aedeagus largest near middle, narrowing to a bluntly pointed apex, which bears a pair of short processes on dorsal margin.

This is one of the most brilliantly marked of all the species of the genus. It is recorded from the eastern states and has been taken from oak in different parts of Illinois.

Illinois Records.—Males and females, taken June 14 to November 19, are from Alton, Ashley, Dubois, Grand Tower, Havana, Herod, Karnak, Makanda, Meredosia, Oquawka, St. Anne, Shawneetown, and White Heath.

4. *Eutettix luridus* (Van Duzee)

Thamnottettix lurida Van Duzee (1890b, p. 250).

Length 6 mm. Vertex, pronotum, and scutellum fulvous, elytra testaceous brown, subhyaline on costal area, the commissural spots on the apical half of each clavus and often the apex of scutellum creamy yellow. Face light brown, sutures darker. Female seventh sternite roundedly produced, slightly notched on either side of a short median produced tooth. Each male pygofer hook, fig. 434D, bifid, dorsal fork shorter than ventral, gradually narrowed to form a sharp apex; ventral fork slightly broader than dorsal, almost parallel margined to a sharp apex. Aedeagus largest at middle, narrowing on apical third to a rounded apex; in ventral view appearing bifid on outer third.

This species, taken from oak shrubs, apparently lives upon the host plant. It is recorded only from the eastern states.

Illinois Records.—Males and females, taken April 30 to November 22, are from Alto Pass, Carlinville, Dubois, Metropolis, Oakwood, Paris, Shawneetown, and White Heath.

5. *Eutettix marmoratus* Van Duzee

Eutettix marmoratus Van Duzee (1892c, p. 302).

Eutettix incerta Gillette & Baker (1895, p. 100).

Length 5.5–6.0 mm. Vertex yellow; with a line in the transverse depression, two spots at apex, four spots along the base, and the median impressed line testaceous. Pronotum with traces of six testaceous longitudinal stripes. Elytra subhyaline, with testaceous brown blotches, paler on costa; usually a faint white or pale spot along commissural line on clavus; this obscured in dark-colored males. Female seventh sternite broadly excavated on either side of a short median apical tooth. Each male pygofer hook, fig. 434E, extending almost to apex of pygofer, broadest on outer third. Aedeagus almost parallel margined, with a pair of slender apical processes about one-third the length of the aedeagus shaft.

This species has been collected from oak and is found in rather small numbers upon that plant. It occurs in the eastern states and west to Colorado.

Illinois Records.—ALTON: June 26, 1934, DeLong & Ross, 1 specimen. APPLE RIVER CANYON STATE PARK: July 11, 1934, DeLong & Ross, 1 specimen. OREGON: Aug. 23, 1935, 1 specimen.

6. *Eutettix variabilis* Hepner

Eutettix variabilis Hepner (1942, p. 269).

Length of male 5.5 mm.; female 6.5 mm. Resembling *querci* in general appearance, but larger and with distinctive male genitalia. Vertex about twice as wide as length at middle, almost parallel margined, transverse furrow usually distinct. Vertex, pronotum, and scutellum pale to darker yellow; males darker in color than females. Elytra semihyaline, veins of elytra usually colorous.

Female seventh sternite with posterior margin excavated on each side of a median lobe, which is sometimes notched at middle. Each male pygofer, fig. 434A, long, two-thirds as wide at constriction as length from there to pointed apex; each pygofer hook bifid, dorsal fork curved ventrally just beyond middle and curved posteriorly near apex, ventral fork barely reaching to margin of pygofer, straight or slightly curved anteriorly. Aedeagus long, widest near base,

then almost parallel margined throughout its length to a pair of apical processes, which are about one-third the length of shaft.

This species was recorded previously only from Arkansas.

Illinois Record.—ALTON: June 26, 1934, DeLong & Ross, 1 ♂, 3 ♀.

7. *Eutettix querci* Gillette & Baker

Eutettix querci Gillette & Baker (1895, p. 101).

Length of male 4.75 mm.; female 5.5 mm. Rather uniformly colored, with distinctive male genitalia. Vertex about twice as wide as median length, with a distinct transverse furrow. Vertex, pronotum, and scutellum yellowish green in the male, fulvous in the female. Elytra semihyaline, fulvous in the male, with veins darkened posteriorly, more opaque in the female and tinged with green.

Female seventh sternite with the posterior margin excavated on each side of a rounded median lobe. Each male pygofer hook, fig. 434F, bifid, dorsal fork about twice as long as ventral, almost parallel margined to outer fourth, curved ventrally on outer fourth and posteriorly on outer fifth; prominent teeth along ventral margin; ventral fork slender, and straight to a pointed apex. Aedeagus almost parallel margined throughout to a pair of apical processes, which are about one-third the length of the shaft, in ventral view parallel margined and bifid on outer sixth.

This species was recorded previously from Colorado, New Mexico, and Texas.

Illinois Records.—ALTON: June 26, 1934, DeLong & Ross, 1 ♂, 10 ♀. GOLCONDA: June 22, 1932, Ross, Dozier, & Park, 1 ♂.

92. *CHLOROTETTIX* Van Duzee

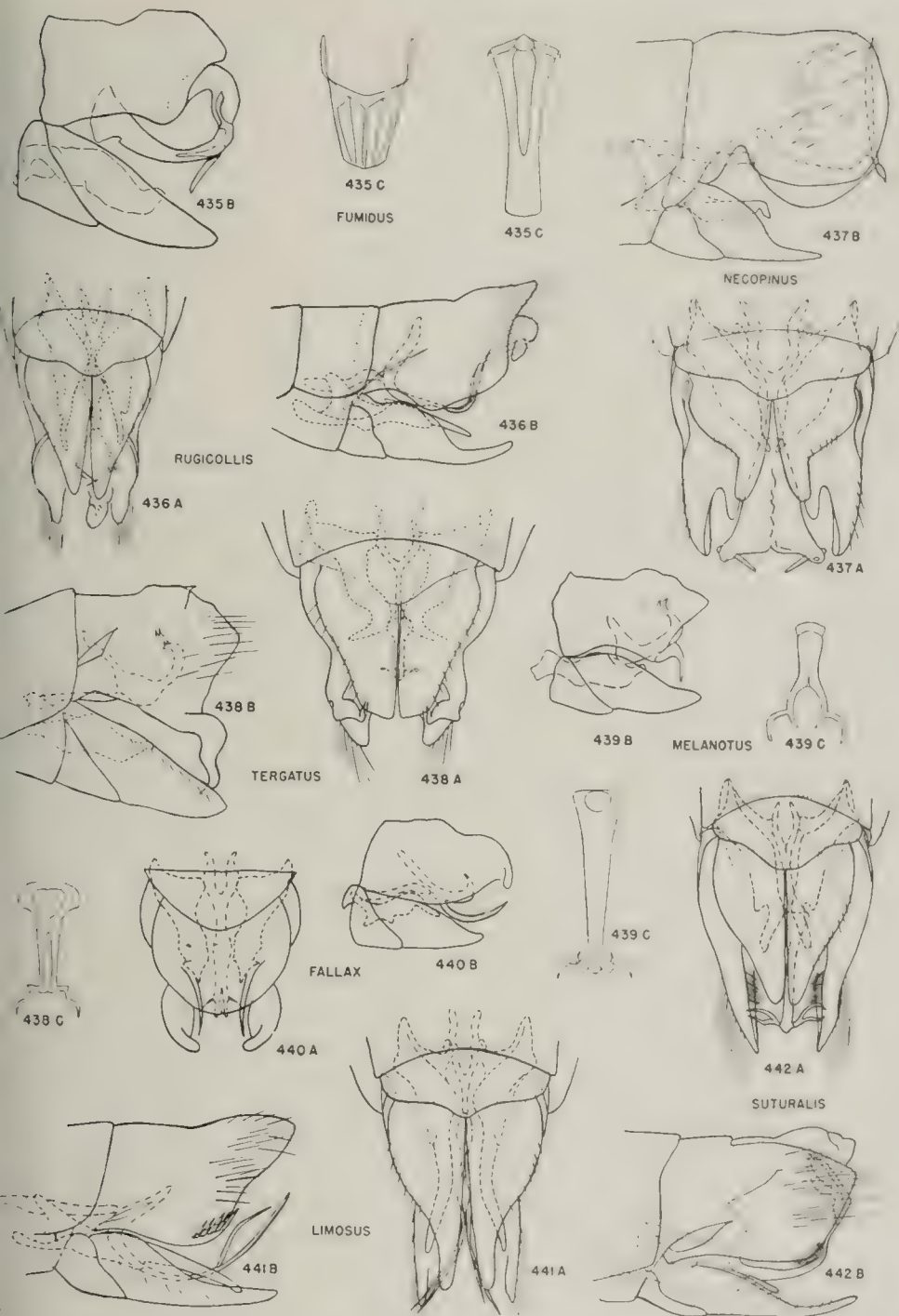
Chlorotettix Van Duzee (1892d, p. 306).

Fig. 204. Vertex varying from broadly rounded to bluntly angled and from a condition where the anterior margins are approximately parallel, to a well-produced vertex with the central portion much longer than next to eyes. Venation of elytra simple. Front broad. Leafhoppers of this genus are usually rather large in size, 6–8 mm., and are of some shade of pale green or yellowish green. Comparatively few bear color markings. They are closely related to certain of the species formerly included in the genus *Thamnotettix*.

More than 50 described species of *Chlorotettix* are now represented in the North American fauna, and half of these have already been taken in Illinois.

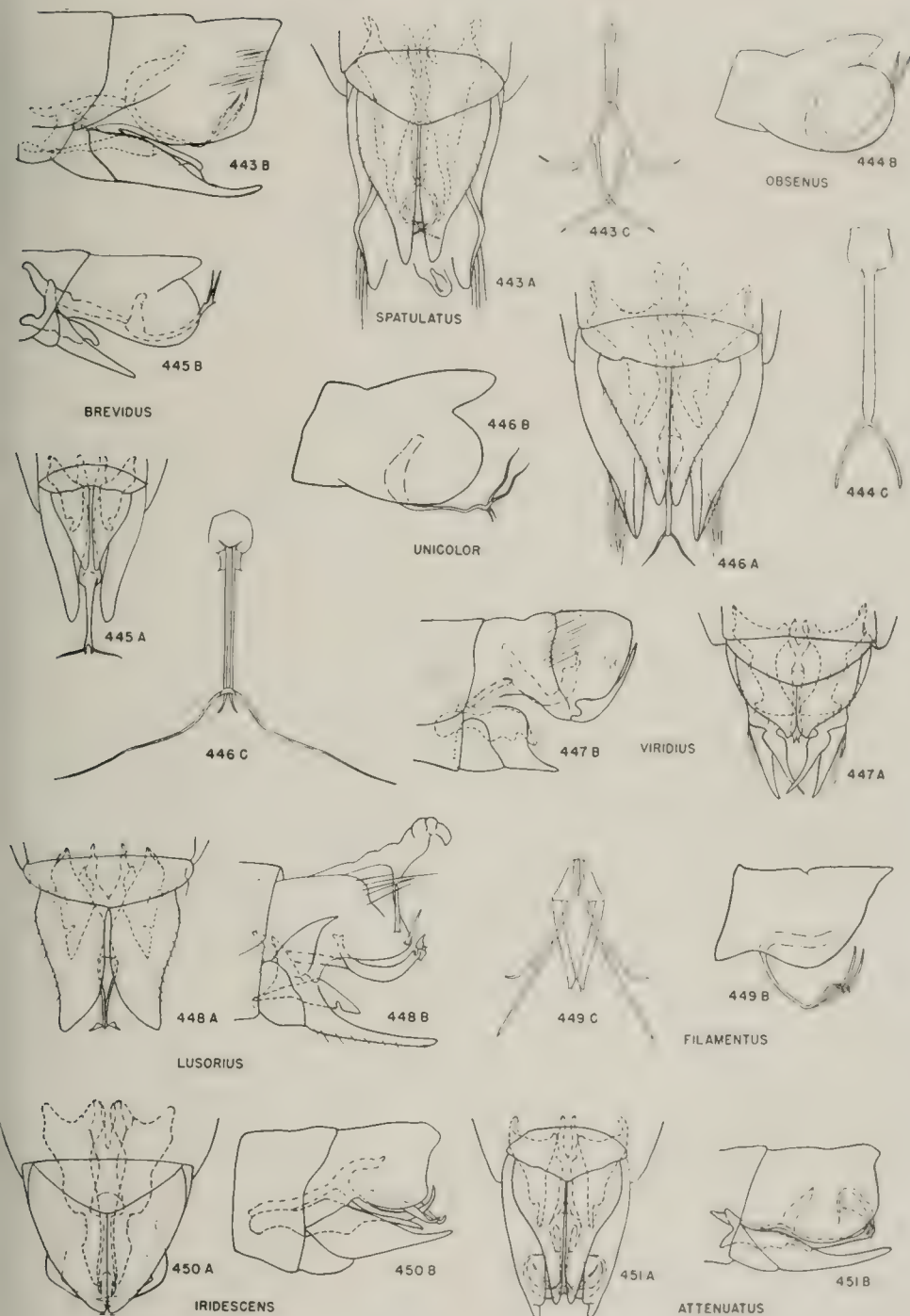
KEY TO SPECIES

1. Vertex with a broad red marginal band between the eyes. **1. rugicollis**
Vertex uniform green or yellowish green, without distinct red marginal band. 2
2. Females. 26
Males. 3
3. Vertex with anterior margin rounded, sometimes broadly rounded; length at middle equaling or slightly exceeding length next to eyes. 4
Vertex with anterior margin distinctly but bluntly angled, length at middle decidedly greater than next to eyes. 16
4. Dark in color, smoky, brownish or sordid green. 5
Lighter in color, some shade of pale green or yellow. 9
5. Vertex with a broad transverse brown band between eyes; elytra dark brown, nervures pale, appearing striped. **2. necopinus**
Vertex without a transverse band between eyes. 6
6. A broad heavy ventrally directed spine arising on the middle of each caudal pygofer margin, fig. 435; apex of aedeagus gradually broadened, with a short straight process on each outer margin. **3. fumidus**
Pygofer spine shorter and narrower, arising on ventrocaudal portion of each pygofer, as in fig. 440. 7
7. Each pygofer spine, fig. 440, narrow, about uniform in width, curved dorsally; aedeagus foot shaped, with the toe turned upward. **4. fallax**
Each pygofer spine broad at base, tapered to slender apex, curved ventrally, as in figs. 438, 439. 8
8. Aedeagus in lateral view, fig. 438, narrowed on apical third, apical processes curved but not branched. **5. tergatus**
Aedeagus in lateral view, fig. 439, not narrow before apical processes, which are branched. **6. melanotus**
9. Vertex with a darker blotch on either side of apex. A smoky to bronze trilobate stripe extending along the claval wing margin. Male aedeagus, fig. 442, with short rather broad bifurcate processes at apex. **7. suturalis**
Vertex without dark blotches; elytra not marked by a sutural stripe. 10
10. Male plates longer than combined basal width, tapered to acute apexes, as in fig. 441. 11
Male plates shorter, combined width at base equaling twice their length, apexes broadly, convexly rounded, as in fig. 447. 15
11. Terminal filamentous aedeagus processes bifurcate or branched, as in fig. 441. 12



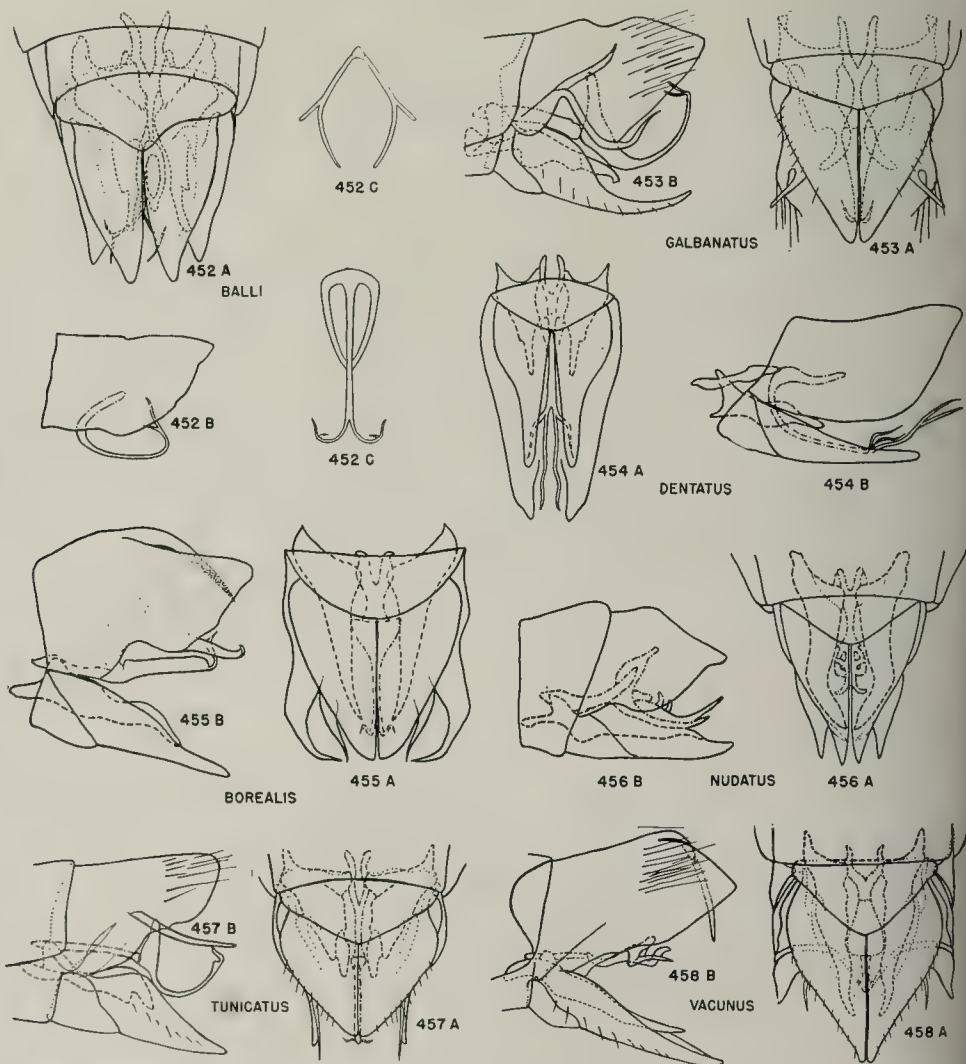
Figs. 435-442.—*Chlorotettix*, male genitalia. A, ventral aspect; B, lateral aspect; C, apical portion of aedeagus.

- Terminal filamentous aedeagus processes not branched or bifurcate. 13
12. Styles, fig. 441, extending beyond plates, conspicuous as black processes. Plates produced as narrow tips. Aedeagus with bifurcate slender terminal processes three times the length of the body of aedeagus. **8. limosus**
 Styles, fig. 443, shorter, not visible beyond plates. Apexes of plates more pointed and not so greatly produced. Aedeagus with bifurcate terminal processes that are less than twice the length of the body of aedeagus. **9. spatulatus**
13. Aedeagus with a pair of very short processes between the longer processes at the end of the body of aedeagus, outer processes more than half as long as body of aedeagus, as in fig. 445. 14
 Aedeagus, fig. 444, without short processes between terminal processes of aedeagus body; terminal processes not more than half as long as body of aedeagus. **10. obsenus**
14. Terminal aedeagus processes, fig. 445, decidedly shorter than aedeagus body. **11. brevidus**
 Terminal aedeagus processes, fig. 446, at least as long as body of aedeagus. **12. unicolor**
15. Each male plate, fig. 447, broader at base than long. Each style short, broad, broadly truncate at apex. **13. viridius**
 Each male plate, fig. 440, more broadly and convexly rounded at apex, length equaling basal width. Each style long, broad, notched on outer margin near apex, which is abruptly narrowed and sharp pointed. **4. fallax**
16. Vertex usually with a distinct brown median transverse band between eyes. **14. lusorius**
 Vertex without a transverse brown band. 17
17. Uniformly bronze iridescent in color. **15. iridescens**
 Not bronze iridescent, usually lighter, some shade of green or yellow. 18
18. Styles distinctly notched on outer margins near apexes, forming a straight or curved finger-like process on inner margin, as in fig. 451. 19
 Styles not notched on outer margin near apexes, gradually tapering to blunt apexes, as in fig. 455. 23
19. Terminal processes of aedeagus branched or bifurcate. 20
 Terminal processes of aedeagus not branched or bifurcate. 22
20. Each pygofer, fig. 451, rounded caudally, shallowly and concavely indented on dorsal half. **16. attenuatus**
 Each pygofer sloping obliquely from rounded ventrocaudal margin to produced dorsocaudal margin, as in fig. 452. 21
21. Apical processes, fig. 452, short, not exceeding one-third of ventral aedeagus body, with very short lateral branches on outer margins at middle. **17. balli**
- Apical processes, fig. 449, long, about equaling length of ventral aedeagus body; lateral branches about one-third the length of apical processes and arising about one-third the distance from base. **18. filamentus**
22. Finger process at apex of each style, fig. 453, curved outwardly, apex of aedeagus with two processes. **20. galbanatus**
 Finger process at apex of each style, fig. 454, longer, straight; apex of aedeagus with four processes. **19. dentatus**
23. Each pygofer, fig. 455, with two spines, a conspicuous dorsal spine curved ventrally and a conspicuous ventral spine curved dorsally. **21. borealis**
 Each pygofer, fig. 456, with not more than one caudal spine. 24
24. Each pygofer, fig. 456, sloping on dorsal and ventral surfaces to a bluntly pointed apex, without a caudal spine. **22. nudatus**
 Each pygofer with caudal spine, as in fig. 457. 25
25. A long spine, fig. 458, on dorsal margin of each pygofer directed ventrally. **23. vacunus**
 A long straight spine, fig. 457, arising on ventrocaudal margin of each pygofer and directed caudad. **24. tunicatus**
26. Vertex with anterior margin rounded, sometimes broadly rounded, length at middle equaling or slightly exceeding length next to eyes. 27
 Vertex with anterior margin distinctly but bluntly angled, length at middle decidedly greater than next to eyes. 37
27. Dark in color, smoky, brownish, or sordid green. 28
 Lighter in color, some shade of pale green or yellow. 31
28. Vertex with a broad transverse brown band between eyes; elytra dark brown, nervures pale, appearing striped. **2. necopinus**
 Vertex without a transverse band between eyes. 29
29. Length 7.5-8.0 mm. **3. fumidus**
 Length not over 7.0 mm. 30
30. Sordid green; northern in distribution. **5. tergatus**
 Usually darker, tinged with black; southern in distribution. **6. melanotus**
31. Seventh sternite deeply notched on either side of a central spatulate process extending from apex of notch, as in fig. 459C. 32
 Seventh sternite notched or excavated but without a spatulate process, as in fig. 460G. 35
32. Spatulate process of seventh sternite cleft at apex, fig. 460N. **8. limosus**
 Spatulate process not cleft at apex, fig. 459C. **9. spatulatus**
33. Seventh sternite deeply, broadly notched, each side of notch bearing a lateral median tooth, fig. 460G. **13. viridius**
 Seventh sternite broadly, concavely rounded or notched but without teeth on lateral margin. 34



Figs. 443-451.—*Chlorotettix*, male genitalia. A, ventral aspect; B, lateral aspect; C, apical portion of aedeagus.

34. Vertex with a darker blotch on either side of apex; a smoky to bronze trilobate stripe extending along the claval margin of each elytron. **7. suturalis**
Vertex without dark blotches; elytra not marked by sutural stripes. 35
35. Seventh sternite broadly, concavely rounded with a narrow V-shaped notch at apex, the entire concave margin dark brown, fig. 459E. **4. fallax**
Seventh sternite broadly, angularly excavated, side of notch sloping to a narrow V-shaped notch at apex, as in fig. 460M. 36
36. Length 6.5–7.0 mm., darker green, veins dark green. **10. obsenus**
Length 7.5–8.0 mm., usually yellowish green in color. **12. unicolor**, **11. brevidus**
37. Vertex usually with a distinct brown median transverse band between eyes. **14. lusorius**
Vertex without a transverse brown band. 38
38. Uniformly bronze iridescent in color. **15. iridescens**
Not bronze iridescent, usually lighter, some shade of green or yellow. 39
39. Seventh sternite deeply notched each side of a median spatulate process, which is produced from the apex. 40
Seventh sternite without a spatulate process. 41
40. Spatulate process, fig. 459A, short and broad. **16. attenuatus**
Spatulate process, fig. 460E, longer, more slender. **17. balli**



Figs. 452–458.—*Chlorotettix*, male genitalia. A, ventral aspect; B, lateral aspect; C, aedeagus.

41. Seventh sternite, fig. 459B, roundedly produced, with a small median notch and a larger one on either side forming a pair of short blunt approximate teeth **19. dentatus**
Seventh sternite notched or elevated, not produced, and without produced teeth 42
42. Seventh sternite appearing somewhat truncate, with a deep notch at middle 43
Seventh sternite not appearing truncate, but notched or excavated from the rather narrow lateral angles 44
43. Posterior margin of seventh sternite, fig. 459D, slightly indented between posterior angles, with a broad V-shaped notch at middle extending two-thirds the distance to base **21. borealis**
Posterior margin, fig. 460C, slightly, convexly rounded either side of a deep narrow U-shaped notch extending two-thirds the distance to base **20. galbanatus**
44. Length not over 6.5 mm. 45
Length 7.0 mm. or more 46
45. Lateral margins of notch of seventh sternite, fig. 460I, evenly, convexly narrowed, apex pointed **23. vacunus**
Lateral margins of notch, fig. 460J, concavely rounded near posterior margin of sternite, then convexly rounded to a rounded apex **25. distinctus**
46. Seventh sternite, fig. 460K, with posterior margin in the form of a brace sign, broadly concave, with a short median notch, the entire margin heavily embrowned **22. nudatus**
Seventh sternite, fig. 460L, with posterior margin broadly, concavely rounded with a brown V-shaped spot at apex **24. tunicatus**

Aedeagus with four long processes at apical end that are bent dorsally; basal third of aedeagus also curved dorsally, the sides nearly parallel.

This species is a common grass association species in Florida and along the Gulf Coast

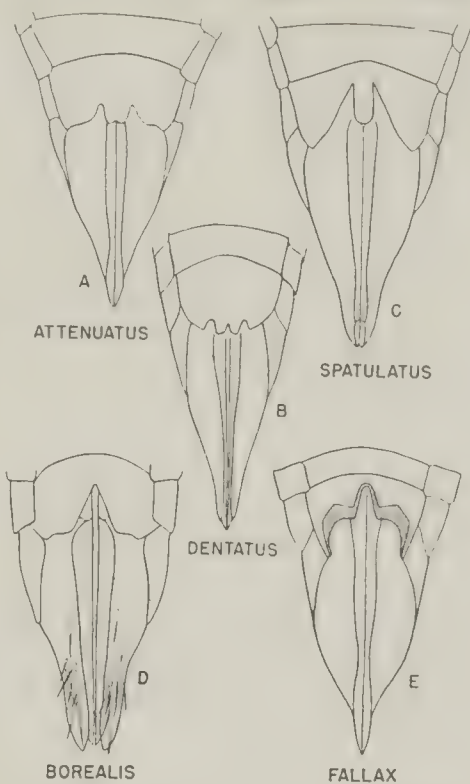


Fig. 459.—*Chlorotettix*. A-E, female genitalia.

1. *Chlorotettix rugicollis* Ball

Chlorotettix rugicollis Ball (1903, p. 230).

Length 7 mm. Pale green, resembling *spatulatus* but with a broader vertex and a conspicuous red or pale orange transverse band on the margin of the vertex and front between the eyes; specimens from the Gulf of Mexico area are more darkly marked. The elytra of the males are often tinged with tawny brown. Vertex broadly rounded, only slightly longer at middle than next to eyes, about two and one-half times wider than long, evenly rounded to front.

Female seventh sternite deeply and triangularly excavated, with a strap-shaped tooth similar to that in *spatulatus* extending posteriorly from the apex of excavation. Male plates, fig. 436, long, triangular. Style elongate, triangular, gradually sloping from base to narrowed produced finger-like apex.

and southern Atlantic Coast. Its occurrence in the old lake basin south and west of Chicago is unusual and interesting, but it is found in an association with several other Florida species of leafhoppers.

Illinois Records.—ALSIP: Aug. 23, 1934, DeLong & Ross, 6♂, 7♀. EVERGREEN PARK: Aug. 23, 1934, DeLong & Ross, 42♂, 52♀. GIBSONIA: Oct. 2, 1934, DeLong & Ross, 1♀. OAK LAWN: in lamp globe, Aug. 22, 1934, DeLong & Ross, 36♂, 11♀. OQUAWKA: scrub oak, July 3, 1934, DeLong & Ross, 1♂, 1♀. ST. ANNE: July 20, 1934, DeLong & Ross, 1♂; Aug. 21, 1934, DeLong & Ross, 11♂, 7♀. SUMMIT: July 17, 1935, DeLong & Ross, 5♂, 5♀. WAUKEGAN: Aug. 24-26, 1917, 5♂. ZION: July 16, 1936, DeLong & Ross, 1♂.

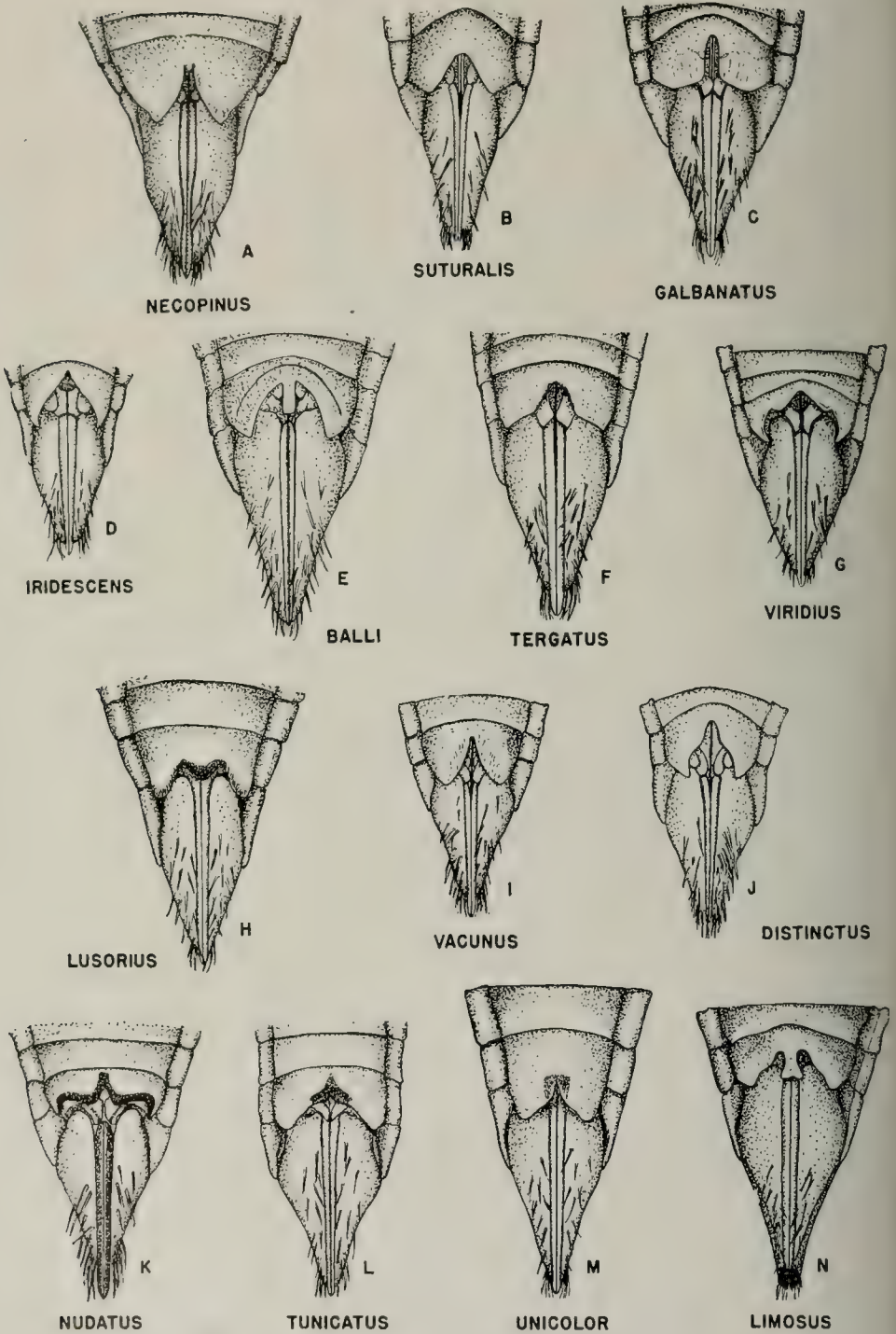


Fig. 460.—*Chlorotettix*. A-N, female genitalia.

2. *Chlorotettix necopinus* Van Duzee

Chlorotettix necopinus Van Duzee (1893, p. 282).

Length 6.5-7.5 mm. Greenish testaceous, with a broad transverse blackish band on disc between eyes, elytra fuscous brown, with white nervures. Posterior margin of seventh sternite of female, fig. 460*A*, deeply and rather broadly incised nearly to its base. Male plates, fig. 437, broad at bases, suddenly constricted and then produced, tips divergent. Aedeagus in ventral view greatly broadened at apex; in lateral view narrowed toward apex, with a long spine on either side directed dorsally and extending to dorsal margin of pygofer, which is broadly rounded caudally. Styles rather short, broad at bases, tapered to pointed apices that are convergent.

A common species in grassy meadows in the southern United States, *necopinus* occurs in the southern part of Illinois in wooded grassy areas.

Illinois Records.—Males and females, taken June 14 to October 2, are from Cave in Rock, Dixon Springs, Eichorn, Elizabethtown, Fern Cliff, Golconda, Herod, Jonesboro, Mount Carmel, Shawneetown, and Vienna.

3. *Chlorotettix fumidus* Sanders & DeLong

Chlorotettix fumidus Sanders & DeLong (1919, p. 237).

Chlorotettix fuscus Brown (1933, p. 243).

Length 7.5-8.0 mm. Smoky green, resembling *tergatus* in form and coloration. Vertex produced, one-half longer at middle than next to eyes and about twice as wide as long. Elytra dark, smoky. Posterior margin of female seventh sternite truncate or slightly concave, with a broad deep median notch at middle extending two-thirds the distance to base. Male plates, fig. 435, short and broad, convexly rounded to appressed tips. Aedeagus with apex broadened and bearing a pair of dorsally directed processes on outer margins of broadened portion. A heavy elongate spine arising from caudoventral concavity of each pygofer and curved ventrally.

This species is found in coarse grasses, usually in marshy or swamp habitats. It is recorded only from Pennsylvania and Tennessee.

4. *Chlorotettix fallax* Sanders & DeLong

Chlorotettix fallax Sanders & DeLong (1922, p. 94).

Chlorotettix latifrons Sanders & DeLong (1922, p. 95).

Length 7.5-8.0 mm. Large, dull greenish yellow, with broadly rounded vertex, twice as wide as long, and elytra smoky at apexes. Female seventh sternite, fig. 459*E*, with posterior margin strongly, concavely excavated half way to base, with a V-shaped notch at middle extending entirely to base; posterior margin and notch broadly bordered with dark brown. Male plates, fig. 440, strongly, convexly rounded, semicircular in outline, width of plates at bases together twice their length. Each pygofer sloping ventrally and dorsally to bluntly pointed apex, a long, curved spine arising from ventrocaudal margin. Aedeagus foot shaped, with the toes turned upwards. Each style rather broad, notched near base on inner margin and near apex on outer margin, abruptly sloping from both margins to form pointed apex.

This species occurs on the coarse sedges of both the fresh-water and salt marsh. It was first described from specimens taken at the margin of the salt marsh in Virginia and from the Gulf Coast of Mississippi, also from specimens taken in the heart of the Florida everglades. In Illinois it occurs in the marsh habitat of the Chicago area.

Illinois Records.—OAK LAWN: in lamp globe, Aug. 22, 1934, DeLong & Ross, 1 ♀; Sept. 6, 1935, T. H. Frison, 2 ♂, 4 ♀. OQUAWKA: July 30, 1936, Mohr & Burks, 1 ♀. SUMMIT: Aug. 21, 1935, DeLong & Ross, 1 ♀. WAUKEGAN: Aug. 5, 1935, Ross & DeLong, 1 ♀.

5. *Chlorotettix tergatus* (Fitch)

Bythoscopus tergatus Fitch (1851, p. 58).

Length 7 mm. Large, sordid green, round headed, without definite color markings. Pronotum and scutellum often washed with yellowish green. Elytra usually smoky. Vertex slightly longer at middle than next to eyes, a little more than twice as wide as long.

Female seventh sternite, fig. 460*F*, twice as long as preceding, posterior margin with a broad V-shaped notch extending half way to the base, lateral lobes rounded. Male

plates, fig. 438, large, broad, covering pygo-fers, apices broad, obtuse. Aedeagus in lateral view broad at middle, with a slender anteriorly and dorsally directed anterior third; posterior third narrowed, curving dorsally; apex with a transverse portion bearing a pair of divergent, spinelike processes on its outer margins, each process sinuate.

This is a common northern swamp and bog species, and so far is not known to occur in any of the southern states. It is found in the tall coarse grass and sedge association in swampy areas or at the margins of tamarack-sphagnum bogs.

Illinois Records.—Many males and females, taken June 27 to October 6, are from Algonquin, Alton, Antioch, Beach, Cedar, Dixon Springs, Dolson, Golconda, Grafton, Grand Detour, Herod, Jonesboro, Kansas, Karnak, McHenry, Monticello, Normal, Oak Lawn, Olive Branch, Palos Park, Princeton, Quincy, Urbana, Vienna, Volo, and Waukegan.

6. *Chlorotettix melanotus* DeLong

Chlorotettix tergatus var. *melanotus* DeLong (1916, p. 84).

Length 7.5 mm. Dark green, resembling *tergatus* so closely in coloration and structural characters that the two can scarcely be distinguished by external characters. Usually *melanotus* is darker in color. Male genitalia, fig. 439, and female seventh sternite very similar to those of *tergatus*. Aedeagus with an enlarged basal portion from which arises a short anterior process directed dorsally; a posterior process of about the same length extends dorsally and is bifurcate at apex, with a curved slender portion arising on the outside of each bifurcate piece near its apex. Each pygofer spine arises ventrally as in *tergatus* but is much smaller; curved, and not sinuate as in that species.

The habitat and distribution pattern of this species are entirely different from those of *tergatus*. This species occurs abundantly in wet pastures and meadows and is sometimes a hillside species in the southern states or southern portions of states just north of the Ohio River.

Illinois Records.—DOLSON: July 24, 1936, DeLong & Mohr, 2♀. KARNAK: July 10, 1935, DeLong & Ross, 2♀.

7. *Chlorotettix suturalis* DeLong

Chlorotettix suturalis DeLong (1916, p. 85).

Length 7.5 mm. Pale green or yellowish, with a median brown line, sometimes only faintly visible, extending along commissural line of each elytron. Vertex bluntly angled. Posterior margin of female seventh sternite, fig. 460B, broadly, deeply notched more than half way to base, the sides dark brown. Male plates, fig. 442, broad and long, convexly narrowed to rounded tips. Aedeagus in lateral view with a long dorsally directed bifid process, each portion of which is bifurcate. Each pygofer with caudal margin almost truncate, obliquely sloping to slightly produced dorsal margin. Styles notched on outer margins near apices, forming curved finger-like apices arising on inner margins and curved outwardly.

This is one of the more common species, occurring in thickets of the cane, *Arundinaria tecta*, which is commonly found in the moist stream floodplains of the southern fourth of the state. Field studies have indicated that it is restricted to this plant host and does not normally occur upon other vegetation. This species was previously reported only from Tennessee.

Illinois Records.—HEROD: Aug. 4, 1934, DeLong & Mohr, 2♂, 4♀; July 8-11, 1935, DeLong & Ross, 2♂; June 24, 1936, DeLong & Ross, 1♂, 3♀. JONESBORO: July 31, 1934, DeLong & Mohr, 1♀. JUSTICE: July 23, 1937, Mohr & Burks, 2♀. NORRIS CITY: June 17, 1934, DeLong & Ross, 1♀. OQUAWKA: July 3, 1934, DeLong & Ross, 1♀. PRINCETON: June 28, 1937, Ross & Burks, 2♂. THEBES: July 11, 1935, DeLong & Ross, 5♂, 4♀. VIENNA: June 14, 1934, DeLong & Ross, 1♂, 3♀; July 29, 1934, DeLong & Ross, 1♂, 2♀; on cane, July 10, 1935, DeLong & Ross, 2♂, 3♀.

8. *Chlorotettix limosus* DeLong & Cartwright

Chlorotettix limosus DeLong & Cartwright (1926, p. 506).

Length 7-8 mm. Broad headed, yellowish green. Posterior margin of seventh sternite of female excavated half way to base on either side of a prominent spatulate process, the latter cleft at apex, cleft extending half the distance of the excavation. Male plates, fig. 441, rather long, convexly rounded two-

thirds their length, then concavely rounded to blunt rounded apices. Aedeagus with two bifurcate terminal processes forming four long straight slender processes. Each pygofer with a long dorsal produced lobe, caudal margin slightly concave. Each style long, apical half slender, produced beyond lateral margin of plate near its apex.

Recorded previously only from Pennsylvania, this species occurs in the fresh-water marsh on coarse grasses in a mixed association of grasses and sedges. It can easily be distinguished by the long slender styles and by the four long terminal processes of the aedeagus.

Illinois Records.—DIXON SPRINGS: July 9, 1935, DeLong & Ross, 1 ♀; June 24, 1936, DeLong & Ross, 1 ♂. KARNAK: Aug. 8, 1934, DeLong & Mohr, 8 ♂, 10 ♀; July 10, 1935, DeLong & Ross, 3 ♂, 4 ♀. SHAWNEETOWN: June 14, 1934, DeLong & Ross, 1 ♀; June 23–27, 1936, DeLong, Ross, & Mohr, 2 ♂, 11 ♀. TEMPLE HILL: June 24, 1936, DeLong & Ross, 1 ♂, 1 ♀. WATSON: Oct. 1, 1934, Frison & Ross, 1 ♀. WOLF LAKE: July 30, 1934, DeLong & Mohr, 2 ♀.

9. *Chlorotettix spatulatus* Osborn & Ball

Chlorotettix spatulatus Osborn & Ball (1897, p. 225).

Length 7 mm. Greenish yellow, broad headed, female seventh sternite with spatulate process. Posterior margin of female seventh sternite, fig. 459C, broadly notched more than half way to base, apex of notch bearing a spatulate process that extends two-thirds the length of the notch. Male plates, fig. 443, broad at bases, acutely pointed. Aedeagus with a pair of bifurcate processes arising at apex, each of these with a long inner branch curved inwardly and an outer shorter branch arising some distance from apex of aedeagus body; short branch curves laterally and is broadened at middle. Each pygofer sloping on caudal margin from curved ventral to produced angled dorsal margin.

A common species of the northern Illinois fresh-water marsh and wet meadow, this species is also frequently found in moist areas of the prairie. It occurs in Florida and is widely distributed in the Middle West.

Illinois Records.—Many males and females, taken June 13 to September 30, are

from Albion, Algonquin, Beach, Cache, Clayton, Des Plaines, Evergreen Park, Fulton, Meredosia, Oak Lawn, Princeton, Rising Sun, St. Anne, Summit, Thomson, Urbana, Waukegan, and Zion.

10. *Chlorotettix obsenus* DeLong

Chlorotettix obsenus DeLong (1937c, p. 52).

Length 7–8 mm. Pale green, with broadly rounded head. Vertex not quite three times as wide between eyes as median length, produced at middle about two-thirds its length before anterior margins of the eyes. Female seventh sternite with lateral margins produced about two-thirds their length, then gradually and obliquely sloping to form produced lobes, between which the margin is excavated about one-third the distance to base; posterior margin gently sloping to the central fourth, which is more abruptly and almost concavely notched; base of the broad V-shaped notch brownish. Male plates, fig. 444, triangular, about as long as combined basal width, greatly exceeded by pygofers. Aedeagus, in ventral view, constricted at about two-thirds its length, then bifurcate, forming two slender terminal processes, which are not more than half as long as the basal portion.

Described from Illinois, this is a marsh species occurring on coarse grasses in grass-sedge habitats.

Illinois Records.—ST. ANNE: July 20, 1934, DeLong & Ross, 1 ♂. ZION: July 6, 1932, Frison *et al.*, 1 ♀; July 25, 1934, Frison & DeLong, 3 ♂, 3 ♀.

11. *Chlorotettix brevidus* DeLong

Chlorotettix brevidus DeLong (1937c, p. 52).

Length 6.5–7.0 mm. Bright green, tinged with yellow, and with a broadly rounded vertex, which is three times as wide between eyes as length at middle. Female seventh sternite with posterior margin shallowly concave between a pair of broad slightly produced lobes; between the inner pair the segment is deeply notched more than one-third the distance to the base; sides of the V-shaped notch are straight and the apex brownish. Male plates, fig. 445, triangular, sharply angled at apices. Ventral margins of ninth sternite not overlapping but forming a keel, which is conspicuous caudad of the plates. Also the caudal notch in the

pygofer near the posterior margin is shorter and more sharply notched at base than in *unicolor*. Aedeagus is the same form and type as in *unicolor*, but the terminal processes are proportionately shorter, in every case being conspicuously shorter than the basal portion of the aedeagus.

This species occurs on grasses of the sand prairie. It is known only from Illinois.

Illinois Records.—OAK LAWN: sand prairie, July 27, 1934, 1 ♀. THOMSON: sand prairie, July 8, 1934, DeLong & Ross, 3 ♂, 6 ♀. ZION: July 25, 1934, Frison & Lee, 1 ♂.

12. *Chlorotettix unicolor* (Fitch)

Bythoscopus unicolor Fitch (1851, p. 58).

Chlorotettix wanduzeei Baker (1898d, p. 219).

Length 7.5 mm. Green or yellowish, broad headed. Posterior margin of female seventh sternite, fig. 460M, broadly, shallowly notched, narrowed and sharp at apex. Male plates, fig. 446, broad at base, outer margins of each concave on apical half, apices produced and divergent. Pygofers deeply notched on caudal margins. A pair of very short processes at end of body of aedeagus; also a pair of long processes arising and extending laterally, these processes as long as ventral portion of aedeagus body. Each style short, broad at base, notched on outer margin near apex.

This is a large and common species in the northern United States, occurring in the fresh-water marsh and in coarse meadow grasses.

Illinois Records.—Many males and females, taken June 2 to August 24, are from Apple River Canyon State Park, Beach, Carman, Des Plaines, Evergreen Park, Fox Lake, Fulton, Grand Detour, Harvard, Palos Park, Princeton, St. Anne, Summit, Volo, Wauconda, Waukegan, and Zion.

13. *Chlorotettix viridius* Van Duzee

Chlorotettix viridius Van Duzee (1892d, p. 309).

Length 6–7 mm. Round headed, apple green. Posterior margin of female seventh sternite, fig. 460G, broadly excavated almost to base, the sides of incisure interrupted at middle by a short obtuse blackish tooth. Male plates, fig. 447, nearly rectangular, transverse, a little longer than valve, apices of plates slightly produced and divergent.

Aedeagus in lateral view constricted near apex, forming a dorsally directed finger-like apex that appears bifid in caudal view. Each style short, broad at base, slightly narrowed between base and apex, which is again broadened and almost truncate. Pygofers with long spines arising ventrally and extending dorsally and caudally.

This is a common species of meadows, pastures, and grassy areas in the eastern and southern states and occurs abundantly in portions of Illinois.

Illinois Records.—Many males and females, taken March 11 to October 2, are from Adair, Albion, America, Beardstown, Bloomington, Carbondale, Carman, Cave in Rock, Centralia, Dongola, Dubois, DuQuoin, Edgewood, Eichorn, Elizabethtown, Evergreen Park, Fairfield, Fern Cliff, Fulton, Geff, Golconda, Grafton, Harrisburg, Havana, Herod, Homer, Kampsville, Karnak, Lawrenceville, Macomb, Marshall, Metropolis, Mount Carmel, Oquawka, St. Anne, Shawneetown, Thebes, Urbana, Vienna, Watson, and York.

14. *Chlorotettix lusorius* (Osborn & Ball)

Thamnotettix lusoria Osborn & Ball (1897, p. 226).

Length 7–8 mm. Olive brown, with a faint crescentiform band before the eyes; vertex produced, twice as wide as long. Elytra with a dull reddish tinge. Posterior margin of female seventh sternite, fig. 460H, emarginate, with a broad angularly pointed dark margined median tooth half as long as the acutely rounded lateral angles. Male plates, fig. 448, one-half longer than broad at bases, outer margins thickened, apices bluntly pointed and strongly divergent. Aedeagus with a short lateral process extending laterally on either side at apex. Styles short, each broad at base and triangular, with a short V-shaped notch on outer margin of each near apex. Each pygofer a little longer on ventral than on dorsal margin, two spines arising on ventral half.

This species is usually found in the herbaceous growth of open woodland areas in the northern United States and Canada. It has been taken frequently in Illinois in habitats of this type.

Illinois Records.—Males and females, taken June 11 to October 2, are from Apple River Canyon State Park, Dolson, Herod,

Hopedale, Marshall, Monticello, Muncie, Oakwood, Temple Hill, Urbana, and White Heath.

15. *Chlorotettix iridescens* DeLong

Chlorotettix iridescens DeLong (1916, pp. 83, 86).

Length 7 mm. Bronze or brownish, tinged with green, appearing iridescent. Vertex one-third longer at middle than next to eyes, more than twice as wide as long. Female seventh sternite, fig. 460D, broadly, deeply excavated to base, sides of excavation concave, convex near apex, forming long rather sharply rounded lateral angles. Male plates, fig. 450, broad and rather short, convexly rounded, with bluntly angled apices. Styles long, apices bluntly angled, each broadly and concavely notched on outer margin about one-third the distance from apex. Aedeagus in lateral view with a dorsal anterior process, body curving ventrally and caudally, apex bifid. Each pygofer concave on caudal margin; spines arising on ventrocaudal margin and hooked at the apices.

This species occurs in abundance in the floodplain woods on grasses in a mixed habitat of grasses, cane, violets, and similar plants of the wet soils of this habitat. It was previously recorded from Maryland and Tennessee.

Illinois Records.—BEARDSTOWN: Sept. 1, 1939, Ross & Riegel, 2♂, 1♀. DIXON SPRINGS: July 29, 1934, DeLong & Ross, 1♂, 3♀. HEROD: Aug. 4, 1934, DeLong & Ross, 30♂, 36♀.

16. *Chlorotettix attenuatus* Brown

Chlorotettix attenuatus Brown (1933, p. 241).

Length 6.75–7.0 mm. Yellowish green, with dark eyes. Vertex bluntly angled, one-half longer at middle than next to eyes. Female seventh sternite, fig. 459A, with posterior margin excavated to about one-half the length of the segment and bearing a short spatulate process, which is about as wide as long. Male plates, fig. 451, broad at bases, slightly narrowed to long acute apices, which about equal the pygofers. Each style long and abruptly narrowed at about middle, apical third spinelike and curved outwardly. Aedeagus long in lateral view, with an anterior dorsally curved broadened portion; apex with a pair of short

dorsally curved processes, and a pair of long processes extending dorsally and broadly curved with pointed apices directed ventrally; in ventral view with a pair of lateral outwardly directed spines, from near the base of which a long tapering process arises each side of middle and extends anteriorly, with a recurved apex.

Described from Missouri, this species is now recorded from Illinois.

Illinois Records.—DIXON SPRINGS: June 24, 1936, DeLong & Ross, 1♂. KARNAK: July 10, 1935, DeLong & Ross, 2♀. SHAWNEETOWN: June 23, 1936, DeLong & Ross, 8♂, 25♀.

17. *Chlorotettix balli* Osborn

Chlorotettix balli Osborn (1898, p. 246).

Length 7.0–7.25 mm. Yellowish green. Vertex angularly produced, one-half longer at middle than next to eyes. Female seventh sternite, fig. 460E, with a deep notch extending almost to the base and including a spatulate process; sides of process straight, lateral margins angled. Male plates, fig. 452, gradually narrowed to acute apices. Aedeagus with a pair of bifurcate processes at apex. Each style broad at base, concavely narrowed to straight finger-like process. Pygofers slightly concave on posterior margins, angled with dorsal margins.

Recorded previously from Tennessee, Ohio, and Iowa, this is a rather common species in open woodland or flat marshy meadow on thick luxuriant growths of mixed grasses.

Illinois Records.—Many males and females, taken June 5 to August 22, are from Alton, Apple River Canyon State Park, Cave in Rock, Dixon Springs, Dolson, Elizabethtown, Farina, Galena, Golconda, Hardin, Herod, Justice, Kankakee, Metropolis, Monticello, Norris City, Oakwood, Pike, Rock Island, Shawneetown, Temple Hill, Urbana, Vienna, and White Pines Forest State Park.

18. *Chlorotettix filamentus* DeLong

Chlorotettix filamentus DeLong (1937c, p. 53).

Length 7 mm. Green, tinged with yellow, and with produced bluntly angled vertex, which is twice as wide between eyes as median length. Each male plate, fig. 449, triangular, outer margin convexly rounded at base, then concavely rounded before

apex, which is narrow but bluntly rounded; combined width at base a little greater than length. Aedeagus similar in type to that of *balli* but differing by having the inner branch of each bifurcate process at the apex at least twice as long as the corresponding branch in *balli*, and the outer branch is at least four times as long as the corresponding process in *balli*. Female unknown.

Described from Illinois, this species is known by only three male specimens.

Illinois Records.—HAVANA: Aug. 30, 1917, 1 ♂. MARSHALL: Sept. 27, 1934, Frison & Ross, 2 ♂.

19. *Chlorotettix dentatus* Sanders & DeLong

Chlorotettix dentatus Sanders & DeLong (1923, p. 154).

Length 8 mm. Yellow to green, with a roundedly produced vertex, which is twice as wide as long and almost one-half longer at middle than next to eyes. Posterior margin of female seventh sternite, fig. 459B, notched on either side of a pair of rounded slightly produced median teeth on the median fourth; sternite convex ventrally, almost keeled. Male plates, fig. 454, convexly rounded to half their length, then rather abruptly constricted and produced as narrow parallel tips with blunt apices.

Previously recorded from the District of Columbia and Maryland, this species has been taken in Illinois and is found in marshy meadow habitats.

Illinois Records.—KARNAK: Aug. 8, 1934, DeLong & Mohr, 4 ♀; July 10, 1935, DeLong & Ross, 1 ♂.

20. *Chlorotettix galbanatus* Van Duzee

Chlorotettix galbanatus Van Duzee (1892d, p. 310).

Length 6.0–6.5 mm. Yellowish green in color, with an obtusely angled vertex, which is one and one-half times as long at middle as next to eyes. Female seventh sternite, fig. 460C, with a rather broad notch reaching two-thirds the distance to base; lobes on posterior margin laterad of the notch broadly rounded or slightly angled at middle. Male plates, fig. 453, evenly, convexly rounded from bases to apices, inner margins at apices depressed, apices obtusely angled. Aedeagus in lateral view broad at base,

narrowed about middle and produced as a long narrow portion with a pair of processes at apex. Each style broad, rather short, abruptly narrowed on outer margin near apex, forming a curved finger-like process.

This is probably the most common species of the genus, occurring throughout Illinois in pastures and meadows on many types of grasses. It is found in the eastern states and west to Montana.

Illinois Records.—Many males and females, taken June 3 to October 11, are from Algonquin, Alton, Alto Pass, Amboy, Anna, Apple River Canyon State Park, Ashley, Brownfield, Cairo, Carbondale, Carmi, Castle Rock, Champaign, Cobden, Danville, Dixon Springs, Dolson, Dongola, Dubois, Duncans Mills, Eichorn, Elizabethtown, Fairfield, Fern Cliff, Fulton, Galena, Gibsonia, Golconda, Grafton, Grand Detour, Grand Tower, Hardin, Havana, Herod, High Knob, Justice, Jonesboro, Kampsville, Kankakee, Karnak, Lima, Marshall, Meredosia, Metropolis, Monticello, Mount Carmel, Muncie, New Holland, Norris City, Oak Lawn, Oakwood, Olive Barnch, Oquawka, Pike, Princeton, Quincy, Ripley, Rock Island, St. Anne, St. Joseph, Savanna, Shawneetown, Spring Valley, Starved Rock State Park, Sumner, Sun Lake, Temple Hill, Urbana, Ursa, Vandalia, Vienna, Villa Ridge, Warren, Watson, White Heath, White Pines Forest State Park, and Wolf Lake.

21. *Chlorotettix borealis* Sanders & DeLong

Chlorotettix borealis Sanders & DeLong (1917, p. 92).

Length 6.0–6.5 mm. Greenish yellow, with dark eyes. Vertex obtusely angled, one-half longer at middle than next to eyes. Female seventh sternite, fig. 459D, with posterior margin truncate and with a narrow median V-shaped notch extending half way to base. Male plates, fig. 455, broad at bases, convexly rounded to obtusely angled apices. Aedeagus in lateral view with small upturned process at apex. Styles long, gradually narrowed to attenuated apices. Pygofers each with a long spine on dorsal side separated by a deep notch, and a long spine on ventral margin extending dorsally.

In Illinois this species has been taken on fine grasses in sandy areas in open wood-

land. It was previously recorded from Wisconsin.

Illinois Records.—Males and females, taken July 8 to October 2, are from Cave in Rock, Dixon Springs, Dolson, Elizabethtown, Grand Detour, Oregon, St. Anne, Springfield, and Vienna.

22. *Chlorotettix nudatus* Ball

Chlorotettix nudata Ball (1900c, p. 340).

Length 7.5 mm. Green, with a brownish or smoky tint. Vertex twice as long at middle as next to eyes, slightly, conically pointed. Female seventh sternite, fig. 460K, with posterior margin distinctly darker marked and divided into four lobes by a narrow slit in the middle and a pair of broad shallow notches a little more than half way toward the sides. Male plates, fig. 456, broad at bases, convexly and then concavely narrowed to acutely pointed apices. Pygofer sloping ventrally and dorsally to bluntly pointed apices. Styles long, tapered, bent inwardly one-third the distance from apices. Aedeagus bifid at apex.

Recorded previously from Tennessee and Iowa, this species occurs in abundance on grasses in the floodplain woods. It seems to be confined almost entirely to moist woodland areas that support a rich growth of grasses.

Illinois Records.—Males and females, taken June 24 to October 3, are from Danville, Dixon Springs, Dolson, Elmira, Herod, High Knob, Kankakee, Oakwood, Pike, Temple Hill, Urbana, Vienna, and White Heath.

23. *Chlorotettix vacunus* Crumb

Chlorotettix vacuna Crumb (1915, p. 196).

Length 6.0–6.5 mm. Yellowish, tinged with green; vertex bluntly angled, one-half broader than long and one-third longer at middle than next to eyes.

Female seventh sternite, fig. 460I, with posterior margin broadly, somewhat convexly excavated three-fourths the distance to base, lateral lobes bluntly angled. Male plates, fig. 458, broad at bases, outer margins convexly narrowed to near apices, where they are slightly concave to form acute tips. Aedeagus in lateral view narrow at base, broadened at apex, and deeply notched. Styles long and narrow, gradually narrowed from bases to apices. Each pygo-

fer pointed at apex with a long dorsal spine.

This is a grass species occurring in southern areas of Illinois. It was recorded previously from Tennessee, and does not occur in abundance.

Illinois Records.—Males and females, taken June 12 to August 14, are from Dixon Springs, Eichorn, Elizabethtown, Fairfield, Herod, Jonesboro, Karnak, La Rue, and Vienna.

24. *Chlorotettix tunicatus* Ball

Chlorotettix tunicata Ball (1900c, p. 340).

Length 7 mm. Pale yellowish green, with greenish elytra. Vertex produced, one-half longer at middle than next to eyes, twice as wide as long.

Female seventh sternite, fig. 460L, with posterior margin roundedly emarginate one-third the depth of the segment, sometimes slightly notched at middle but always appearing notched because of a brown V-shaped spot at middle of emargination. Male plates, fig. 457, broad at base, roundedly narrowed to a very obtuse, almost truncate apex, plates together the shape of a bluntly pointed spoon. Each pygofer concave on caudoventral margin, with a long straight spine arising in middle of concavity and directed caudally. Aedeagus in lateral view broad at base, apical two-thirds narrow, notched at apex, forming an anteriorly directed short finger-like process. Styles broad at bases, triangular, apices bluntly pointed.

This species occurs on grasses in open woodland areas in the eastern and southern states.

Illinois Records.—Many males and females, taken June 14 to October 8, are from Alton, Amboy, Anvil Rock, Apple River Canyon State Park, Cave in Rock, Dixon, Dolson, Fulton, Havana, Kankakee, Metropolis, Pike, St. Anne, Shawneetown, Temple Hill, Urbana, Vienna, and White Heath.

25. *Chlorotettix distinctus* DeLong

Chlorotettix distinctus DeLong (1919, p. 23).

Length 6 mm. Yellow, tinged with green. Vertex bluntly angulate, almost one-half longer at middle than next to eyes. Female seventh sternite, fig. 460J, with posterior margin deeply and broadly notched two-thirds the distance to base; sides of apical

half straight, basal half with sides concavely rounded to form a bluntly angled lobe on either side.

Described from Tennessee, this species is known only from the female. In Illinois, it occurs only in the southern part of the state.

Illinois Records.—VIENNA: July 29, 1934, DeLong & Ross, 1 ♀. VOLO: July 27, 1934, DeLong & Ross, 1 ♀.

93. *DOLERANUS* Ball

Doleranus Ball (1936, p. 58).

Head conical, venation simple but with central anteapical cell somewhat constricted, then enlarged before the apex. Vertex with a broken submarginal brown line. Three species are included in this genus, two of which are eastern and occur in Illinois.

KEY TO SPECIES

Green in color, without definite markings.....**2. *vividus***
Brownish yellow, marked with reddish brown.....**1. *longulus***

1. *Doleranus longulus* (Gillette & Baker)

Thamnotettix longulus Gillette & Baker (1895, p. 97).

Length 5–6 mm. Brownish yellow, marked with reddish brown. Vertex obtusely angled, twice as wide as long; light fulvous, ocelli white, connected by a white transverse line; median longitudinal line and spot either side at base brown. Pronotum fulvous, marked with dark brown on anterior portion. Scutellum fulvous, disc paler. Elytra chestnut, nervures pale. Female seventh sternite with posterior margin depressed, slightly, angularly elevated. Male plates concavely rounded to the almost parallel-margined tips.

Common on herbaceous plants in open wooded areas, on wooded floodplains, and along stream banks, this species occurs in the eastern states and west to Iowa, Kansas, and Colorado.

Illinois Records.—Many males and females, taken March 27 to November 1, are from Aldridge, Carmi, Cave in Rock, Champaign, Charleston, Cobden, Dongola, Eichorn, Fountain Bluff, Grand Tower, Karnak, La Rue, Marshall, Monticello, Normal, Rock Island, Savoy, Urbana, Vienna, and White Heath.

2. *Doleranus vividus* (Crumb)

Chlorotettix vivida Crumb (1915, p. 197).

Length 5.5–6.0 mm. A distinctly angle-headed greenish species tinged with brown. Vertex one and one-half times as broad as long, almost twice as long at middle as next to eyes. Female seventh sternite with posterior margin broadly, triangularly notched half way to base, with a tooth at apex. Male plates, fig. 247, rather long, gradually narrowed three-fourths their length, then produced with almost parallel margins. Pygofer truncate posteriorly. Aedeagus in lateral view broad at base, narrowed to tapered bifurcate apex. Styles rather short, abruptly narrowed to finger-like apices.

A common species on grassy areas in meadows along streams, in valleys, and in open woodland, *vividus* occurs in the middle western and eastern states.

Illinois Records.—Many males and females, taken June 7 to November, are from Algonquin, Alton, Apple River Canyon State Park, Cave in Rock, Champaign, Danville, Dixon Springs, Dolson, Dubois, Elizabethtown, Fern Cliff, Golconda, Grafton, Havana, Herod, Jonesboro, Kampsville, Kankakee, Karnak, Lima, Monmouth, Monticello, Mount Carmel, Muncie, Normal, Oakwood, Olive Branch, Oquawka, Parker, Pike, Quincy, Rock Island, Thebes, Urbana, Ursa, Vienna, and White Pines Forest State Park.

94. *ATANUS* Oman

Atanus Oman (1937, p. 381).

Fig. 207. Vertex nearly flat, longer at middle than next to eyes, and bluntly angled. Head a little wider than pronotum. Forewing with simple venation, the second cross-vein lacking. The outer anteapical cell is short, with almost parallel sides, and is more slender than inner anteapical cell.

Only one of the two United States species belonging to this genus is known to occur in Illinois.

1. *Atanus perspicillatus* (Osborn & Ball)

Thamnotettix perspicillatus Osborn & Ball (1897, p. 227).

Length 3.5–4.0 mm. A small gray species marked with black spots. Vertex creamy white, tinged with orange, two faint black

lines extending from apex to ocelli, basal half with a large fulvous crescent either side enclosing a white area. Pronotum gray; with broad faint longitudinal bands and a pair of spots behind each eye black. Scutellum pale, basal angles orange. Elytra milky, subhyaline, iridescent, with nine black spots. Vertex slightly longer at middle than next to eyes, a little wider at base than median length. Female seventh sternite broadly, angularly produced. Male valve short and broad; plates long, apices produced into pointed acute tips; a median black spot on each plate at base.

Occurring on herbaceous growth in wooded areas along streams, and in rich herbaceous areas, this species is distributed in parts of the East and Middle West.

Illinois Records.—DARWIN: July 23, 1932, Dozier & Park, 1 ♂. DIXON SPRINGS: July 9, 1935, DeLong & Ross, 1 ♂, 1 ♀. DOLSON: Rocky Branch, July 18, 1934, DeLong & Ross, 3 ♂; July 24, 1936, DeLong & Mohr, 3 ♀. HEROD: June 24, 1936, DeLong & Ross, 1 ♂. MOUNT CARMEL: July 3, 1906, 1 ♀. URBANA: sweeping, July 28, 1889, C. A. Hart, 1 ♂, 4 ♀; Aug. 27, 1916, 3 ♂, 5 ♀; Aug. 16–20, 1934, 3 ♂, 1 ♀. VIENNA: savanna grasses, June 14, 1934, DeLong & Ross, 1 ♂; July 29, 1934, DeLong & Ross, 1 ♂, 1 ♀.

95. *ELYMANA* DeLong

Elymana DeLong (1936a, p. 218).

This genus includes the more pointed-headed species previously included in *Thamnotettix*. Form usually long and slender, vertex sharply pointed or strongly and bluntly produced and acutely angled with front. Elytra long and narrow, venation as in *Thamnotettix*. Last sternite of male long, tapering to a pointed spinelike process. Aedeagus long, tapering to a long slender dorsally directed process. Base of aedeagus with dorsally extending process of various shapes.

DeLong (1936b) recorded five species of this genus for North America. One is known only from Arizona; the other four are eastern in distribution and all occur in Illinois, usually in wooded areas on *Elymus* and related grasses.

The species of the genus are closely related, and the females are very similar in the character of the seventh sternite, the posterior margin of which is usually sinuate.

KEY TO SPECIES

1. Ninth segment of male produced into a sharp-pointed spine at apex. Spines on median dorsal portion visible in lateral view, directed caudad, as in figs. 461B, 461C.....2
- Ninth segment of male tapered, but blunt at apex, apical spines above apex of segment. Median dorsal spines not visible in lateral view, directed laterally into genital chamber, as in figs. 461A, 461D.....3
2. Styles of male, fig. 461B, constricted between bases and enlarged apices, which are sharp pointed on outer margins and slope outwardly.....1. *acrita*
- Styles, fig. 461C, constricted near bases and slightly tapered to almost truncate apices, which are not enlarged.....2. *acuma*

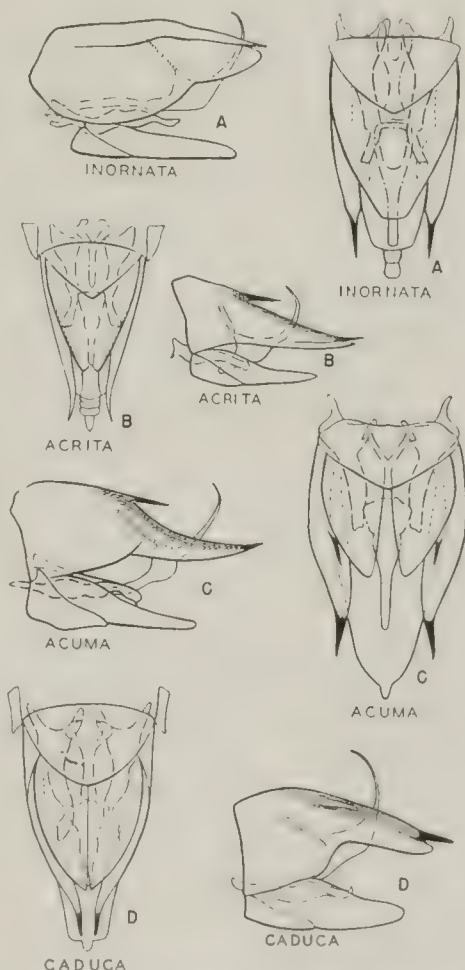


Fig. 461.—*Elymana*. A–D, male genitalia, ventral and lateral aspects.

3. Vertex almost rounded at apex, three-fifths as long as wide. Styles of male, fig. 461D, constricted near apexes, then strongly curved outwardly, enlarged, and truncate on outer margins.....

.....3. *caduca*
Vertex more angled, three-fourths as long as wide. Styles, fig. 461A, constricted near apexes but not enlarged, produced as parallel-sided apexes directed slightly obliquely and truncate at apex.....

.....4. *inornata*

1. *Elymana acrita* DeLong

Elymana acrita DeLong (1936b, p. 637).

Length 4.75–5.0 mm. Yellowish, with black ocelli, vertex sharply angled, almost as long as basal width between eyes. Female seventh sternite shallowly and roundedly emarginate, with a dark spot on either side of middle. Male ninth segment, fig. 461B, sloping to posterior spine, scarcely concave, anterior spine prominent. Styles in ventral view with outer margins sinuate and each tapered to a constricted portion anterior to an enlarged apical process, truncate at apex.

This species was described from Illinois, where it is abundant on *Elymus* grasses in shaded areas, on floodplains, and similar moist soils. It can easily be distinguished from the other members of the genus by characters of the male styles.

Illinois Records.—DIXON SPRINGS: July 9, 1935, DeLong & Ross, 1 ♀. ELIZABETHTOWN: June 25, 1932, Ross, Dozier, & Park, 1 ♂. GOLCONDA: June 22, 1932, Ross, Dozier, & Park, 1 ♀. HEROD: June 23, 1936, DeLong & Ross, 1 ♂. MONTICELLO: June 11, 1934, 3 ♂, 7 ♀. OQUAWKA: June 13, 1932, H. L. Dozier, 1 ♀.

2. *Elymana acuma* DeLong

Elymana acuma DeLong (1936b, p. 637).

Length 5 mm. Yellowish and with black ocelli, slightly larger than *acrita*. Vertex rather sharply angled, only slightly wider between eyes than length at middle. Female seventh sternite truncate, with heavy brown spots on either side of middle. Male ninth segment, fig. 461C, with anterior spine prominent in lateral view, the dorsal margin beyond this strongly and concavely rounded to form the posterior spine. Styles in ventral view rather short, not notched on outer margins, slightly and convexly rounded on inner margins; sides almost parallel, apexes truncate.

This is a southern species, described from Tennessee, and is found on *Elymus* grasses in shady wooded areas.

Illinois Records.—DIXON SPRINGS: July 9, 1935, DeLong & Ross, 1 ♀. ELIZABETHTOWN: June 25, 1932, Ross, Dozier, & Park, 1 ♂. GOLCONDA: June 22, 1932, Ross, Dozier, & Park, 1 ♀. HEROD: June 24, 1936, DeLong & Ross, 1 ♂. OQUAWKA: June 13, 1932, Dozier, 1 ♀.

3. *Elymana caduca* DeLong

Elymana caduca DeLong (1936b, p. 638).

Length 5 mm. Yellow, tinged with green; ocelli black; veins of elytra paler than disc and conspicuous. Vertex bluntly angled, three-fifths as long as basal width. Female seventh sternite truncate or slightly emarginate. Male ninth segment, fig. 461D, strongly convex and rounded dorsally, anterior spine hidden in lateral view, extending inwardly; posterior spine prominent. Styles in ventral view rather deeply notched on outer margins, inner margins strongly convex and curved, apexes turned outwardly, with pointed tips.

This is a common marsh species in northern Wisconsin and occurs at the margins of sphagnum bogs. It is found in similar habitats in northern Illinois.

Illinois Records.—BEACH: Aug. 7, 1935, DeLong & Ross, 1 ♀. VOLO: Aug. 24, 1935, DeLong & Ross, 6 ♀; Aug. 12, 1937, Burks & Ross, 1 ♀. WAUCONDA: July 23, 1934, DeLong & Ross, 1 ♀.

4. *Elymana inornata* (Van Duzee)

Thamnotettix inornatus Van Duzee (1892c, p. 303).

Length 5.0–5.5 mm. Dull yellow, tinged with green, bluntly angled. Vertex one-fourth wider between eyes than length at middle. Female seventh sternite almost truncate, a brown spot on either side of middle, producing notched appearance. Dorsal portion of male ninth segment, fig. 461A, convexly rounded to posterior spine; anterior spine extending inwardly and not visible in lateral view. Styles long, outer margins sloping inwardly to near apexes, where they are notched, and the apexes produced as short rather narrow parallel-margined and divergent processes.

This species is chiefly northern in distribution, occurring commonly at the margin

of the fresh-water marsh or similar moist areas.

Illinois Records.—Males and females, taken June 11 to November 10, are from Apple River Canyon State Park, Cave in Rock, Danville, Dolson, Herod, Kankakee, Marshall, Monticello, Oakwood, Shawneetown, and Urbana.

96. *CICADULA* Zetterstedt

Cicadula Zetterstedt (1838, col. 296).
Cyperana DeLong (1936a, p. 218).

Fig. 462. This genus includes the common green leafhoppers of the *Thamnotettix* type, which occur in fresh-water marshes on *Cyperus*, similar sedges, and coarse grasses; they are characterized by having a bluntly angled vertex, which is usually produced, but in some species the apex is almost rounded. The elytra are long and narrow, with venation as in *Thamnotettix*. In most species of this genus, individuals are some shade of green or yellow, with a black band or a row of black spots on the margin of the vertex between the eyes.

The greater number of species of the genus occur only in the eastern United States, but some occur as far west as the Rocky Mountains. A few of the species are found only in the western United States. DeLong (1937d) recorded 13 species for the United States under the generic name *Cyperana*, and nearly half of these occur in Illinois.

KEY TO SPECIES

- 1. Tawny or pale brown, longitudinally marked with brownish or reddish stripes; spots on vertex linear in form or forming a band, figs. 463*A*, 463*B*. 2
- Yellow or green, without longitudinal stripes 3

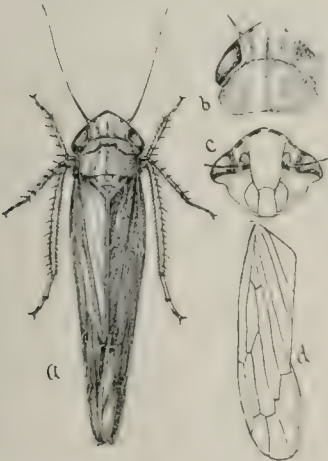
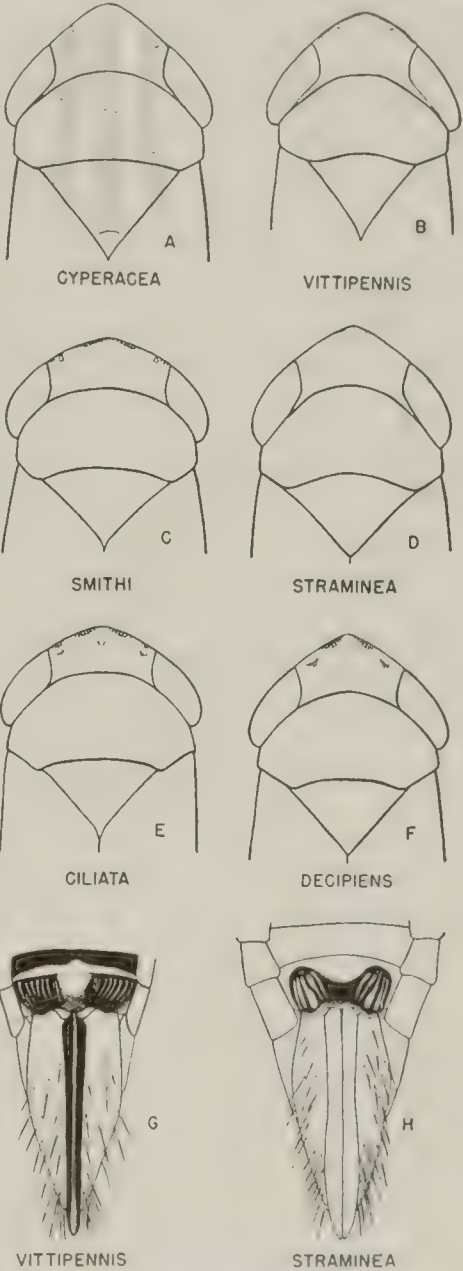


Fig. 462.—*Cicadula cyperacea*: a, adult; b, head and pronotum; c, face; d, elytron. (From Osborn.)

Fig. 463.—*Cicadula*. A-F, head and pronotum; G-H, female genitalia.

2. Vertex with four linear black spots on margin.....**1. cyperacea**
Vertex with a black band on margin.....**2. vittipennis**
3. Length 6.5–7.0 mm.; pale yellow, with a pair of large black spots at apex of vertex and a pair of smaller spots next to eyes.....**3. straminea**
Length not over 6.0 mm.; usually green or yellowish green.....**4. smithi**
4. Black coloration on margin of vertex forming band between eyes.....**4. smithi**
Black coloration on margin of vertex in the form of spots.....**5**
5. Four black spots on margin of vertex but without markings posterior to ocelli.....**6**

Markings on margin of vertex and also posterior to ocelli.....**7**

6. Each male plate, fig. 464A, deeply and concavely excavated on inner margin of apical third; each style tapered from base to apex.....**5. melanogaster**

Each male plate, fig. 464E, sloping on inner margin, not concavely rounded; each style with a pair of finger-like processes at apex, an inner long one and an outer short one.....**6. ciliata**

7. Length 3.5–4.5 mm.; aedeagus, fig. 464C, short, not greatly enlarged at base; occurring in the western United States.....**7. longiseta**

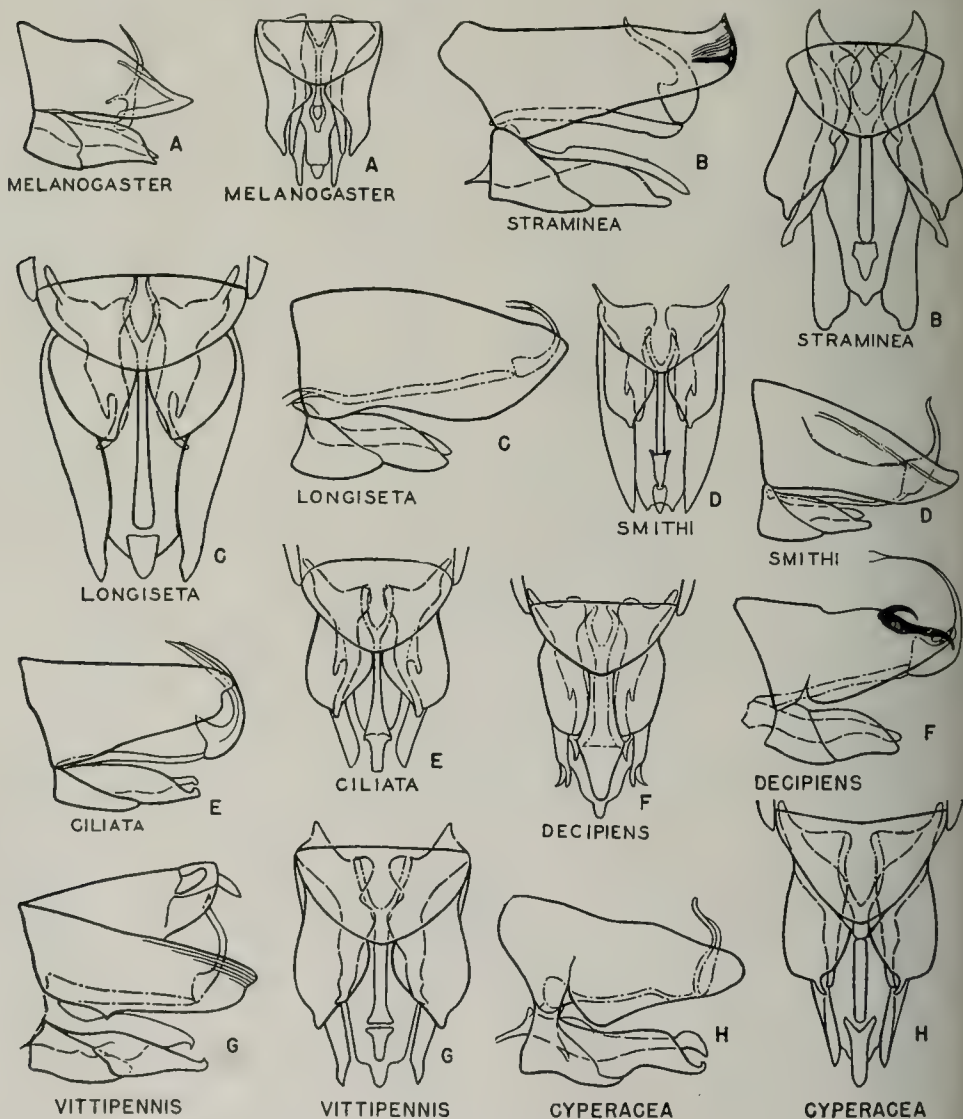


Fig. 464.—*Cicadula*. A–H, male genitalia, ventral and lateral aspects.

Length more than 4.5 mm.; aedeagus long, fig. 464F, large at base, apical two-thirds very slender; occurring in north-eastern United States. . . . 8. *decipiens*

1. *Cicadula cyperacea* (Osborn)

Thamnotettix cyperaceus Osborn (1898, p. 245).

Length 5.5–6.0 mm. Tawny, with orange or brownish longitudinal stripes and four black dashes on margin of vertex, fig. 463A, between the eyes. Vertex flat and bluntly angled, one-half wider between eyes at base than length at middle.

Female seventh sternite with lateral angles broadly rounded, posterior margin slightly, narrowly indented on either side of a broad median slightly produced tooth; median tooth about one-third width of sternite; a large round area on outer third of sternite composed of oblique ridges and striae. Male plates, fig. 464H, rather long and broad, each convexly rounded to blunt apex, where it bears a rather long incurved finger-like process. Each style long, broad on basal half, then rather rapidly narrowed to slender apical processes, which are produced half the length of style. Aedeagus rather small, slightly enlarged at base, apical portion narrowed, produced dorsally, and curved anteriorly.

This species is commonly found in the fresh-water marsh of the northern states in *Cyperus* habitats. It is a fairly common species in the marshes of northern Illinois, and closely resembles *vittipennis*, which is found in the same general type of habitat.

Illinois Records.—ANTIOCH: July 5–7, 1932, T. H. Frison, 1♂. FOX LAKE: June 30, 1935, DeLong & Ross, 4♂, 6♀. ORANGEVILLE: Aug. 28, 1934, Frison & DeLong, 1♂, 1 nymph. URBANA: June 2, 1890, C. A. Hart, 1♂. VOLO: July 16, 1935, DeLong & Ross, 3♂, 1♀; in bog, Aug. 24, 1935, DeLong & Ross, 2♂, 2♀.

2. *Cicadula vittipennis* (Sanders & DeLong)

Thamnotettix vittipennis Sanders & DeLong (1917, p. 91).

Length 5.5–6.0 mm. Tawny, with elytra appearing white striped. Vertex, fig. 463B, with a black marginal stripe between eyes, and a tawny band covering disc and extending to eyes. Vertex bluntly angled, twice as wide between eyes as length at

middle. Female seventh sternite, fig. 463G, with posterior margin slightly emarginate and narrowly notched on either side of middle; outer third striated as in *cyperacea*. Male plates, fig. 464G, short and broad, convexly rounded on each outer margin, and strongly sloping on inner margin to form a blunt toothlike structure at apex. Styles long, sinuately tapered from bases and curving outwardly to form blunt apices, pointed on outer margins. Plates decidedly longer than styles. Aedeagus slender, slightly enlarged at base, normally directed dorsally, curved slightly caudally at middle.

This species has been collected only in northern Wisconsin from the tall grass and sedge habitat of the fresh-water marsh.

3. *Cicadula straminea* (Sanders & DeLong)

Thamnotettix stramineus Sanders & DeLong (1917, p. 90).

Length 6.5–7.0 mm. Large, yellow, with four transverse black spots on margin of vertex, fig. 463D, the inner spots large, the outer two small. Vertex almost twice as broad as median length, bluntly angled. Female seventh sternite, fig. 463H, with outer angles forming broadly rounded lobes, between which the posterior margin is shallowly and concavely rounded; outer third of segment on either side black, with prominent oblique ridges and striae. Male plates, fig. 464B, short, each gradually narrowed on inner margin and convexly rounded on outer to form a prominent pointed projection at apex. Styles long and slender, tapering and slightly constricted just before bluntly pointed apices.

This species inhabits the sedges of the northern marsh areas and may occur in northern Illinois.

4. *Cicadula smithi* (Van Duzee)

Thamnotettix smithi Van Duzee (1892b, p. 266).

Length 5 mm. Green, tinged with yellow, and with a broad black band on margin of vertex, fig. 463C, between the eyes; vertex broadly rounded, almost parallel margined, twice as wide between eyes as length at middle; elytra green, apices smoky. Female seventh sternite with lateral angles broadly rounded, posterior margin slightly

emarginate on either side of a broad slightly produced median tooth, which is produced almost as far as the rounded lateral angles. Each male plate, fig. 464D, short, sides convexly rounded to blunt apex, with a short blunt toothlike projection. Each style rather long, narrowed at about one-third its length and produced to form a spurlike tooth on outer margin and an elongated rather broad finger-like process on inner margin, process blunt at apex. Aedeagus rather short, enlarged at base, narrowed at about half its length to form a slender apical process, which is directed dorsally.

A species occurring in the fresh-water marsh on *Spartina michauxiana*, *smithi* is recorded from the eastern states and the Middle West.

Illinois Records.—CHAMPAIGN: at light, June 12, 1888, 1 ♀. FOX LAKE: June 30, 1935, DeLong & Ross, 1 ♂; June 26, 1936, Frison & DeLong, 4 ♂, 8 ♀. FULTON: July 4, 1936, DeLong & Burks, 1 ♀. PRINCETON: in swamp, July 7, 1934, DeLong & Ross, 1 ♀; July 2, 1936, B. D. Burks, 1 ♀. SUMMIT: Aug. 21, 1935, DeLong & Ross, 1 ♂.

5. *Cicadula melanogaster* (Provancher)

Jassus melanogaster Provancher (1872, p. 378).

Length 5.0–5.5 mm. Greenish or yellowish, with four large black spots in a row on the margin of vertex; vertex bluntly angled, one-half wider between eyes than length at middle. Female seventh sternite with a sinuate posterior margin that is broadly and shallowly emarginate. Male plates, fig. 464A, abruptly and concavely narrowed on inner margins to produced bluntly pointed apices. Styles long and slender, narrowed near bases and produced into long tapering processes with bluntly pointed apices. Aedeagus long, slender, and usually directed dorsally; basal portion a little thicker and with anterior process; apical portion slender and pointed at tip.

This is the most common species of the genus and occurs in the fresh-water marsh of the northern United States. It is found commonly throughout Illinois.

Illinois Records.—Many males and females, taken June 5 to November 17, are from Algonquin, Amboy, Antioch, Atlas, Aurora, Beach, Champaign, Des Plaines, Freeport, Fox Lake, Fulton, Harrisburg,

Havana, Humboldt, Loda, Macomb, New Milford, Ogden, Oquawka, Orangeville, Oregon, Princeton, Round Lake, St. Anne, Seymour, Shawneetown, Spring Valley, Urbana, Vienna, Volo, Warren, Wauconda, and Zion.

6. *Cicadula ciliata* (Osborn)

Thamnotettix ciliatus Osborn (1898, p. 244).

Length 5.0–5.5 mm. Green, tinged with yellow, and with four black spots on margin of vertex, fig. 463E. Vertex blunt, almost twice as wide between eyes at base as length at middle. The margin of the female seventh sternite is broadly and shallowly emarginate. Each male plate, fig. 464E, short and broad, strongly and convexly rounded on outer margin, and strongly sloping on inner margin to a blunt apex with a slight toothlike projection. Aedeagus broad at base, constricted and produced dorsally and anteriorly as a wide blade-like structure that is pointed at apex.

This species occurs on sedges in fresh-water marshes throughout the northern United States.

Illinois Records.—ALGONQUIN: Aug. 13, 1895, 1 ♂; Sept. 15, 1895, 1 ♂, Oct. 3, 1895, 1 ♂. AMBOY: Aug. 8, 1934, DeLong & Ross, 1 ♂. ELIZABETH: July 7, 1917, 1 ♂. FOURTH LAKE: Aug. 7, 1887, 1 ♂. GRAYS LAKE: June 10, 1936, Ross & Burks, 1 ♀. HUMBOLDT: Nov. 1, 1931, H. H. Ross, 1 ♂, 2 ♀. ORANGEVILLE: Aug. 28, 1934, DeLong & Frison, 1 ♀. SAVANNA: June 14, 1917, 2 ♀. URBANA: Oct. 4, 1909, 2 ♀; Nov. 10, 1915, 1 ♀.

7. *Cicadula longiseta* (Van Duzee)

Thamnotettix longiseta Van Duzee (1892b, p. 266).

Length 3.5–4.5 mm. Resembling *melanogaster* somewhat in coloration but with a broad blunt head and a pair of tiny spots back of ocelli in addition to the four on the anterior margin of vertex. Vertex bluntly angled, two-fifths wider between eyes than length at middle. Female seventh sternite sinuate and almost truncate, with posterior margin slightly concave. Each male plate, fig. 464C, short and broad, strongly and convexly rounded on outer and inner margins to form a bluntly pointed apex. Style narrowed gradually from base to form a

long finger-like process on each inner margin, which is strongly curved outwardly, and a much shorter process on outer margin, about one-third the length of the inner process. Aedeagus only slightly enlarged at base, curved dorsally and anteriorly about as far as base, apex bifid.

This is a common species of the genus in the northwestern United States and may occur in western Illinois.

8. *Cicadula decipiens* (Provancher)

Thamnotettix decipiens Provancher (1890, p. 285).

Length 4.5–5.0 mm. Yellow, tinged with green, with four black spots on vertex, fig. 463F, a large one on either side of blunt apex on margin, and one on either side above margin and posterior to ocellus; vertex blunt, almost twice as wide between eyes at base as length at middle. Female seventh sternite with lateral angles rather well produced, between which the posterior margin is sinuately and concavely emarginate more than one-third the distance to base; a very short white blunt tooth at apex of emargination. Male plates, fig. 464F, rather broad and short, convexly rounded to blunt apices. Styles long and narrow, inner margin of each produced into a long curved finger-like process, outer margin with a very short spur only. Aedeagus large at base, rapidly constricted to a very slender apical portion, which is long, curves dorsally and anteriorly, and is bifid at apex. A large black bifurcate spine is on the dorso-caudal portion of each pygofer.

This is a transcontinental species found in the fresh-water marsh on sedges.

Illinois Records.—ANTIOCH: Aug. 24, 1935, DeLong & Ross, 1 ♀. FOX LAKE: June 30, 1935, DeLong & Ross, 1 ♀. PRINCETON: swamp, July 7, 1934, DeLong & Ross, 1 ♂. SUMMIT: Aug. 21, 1935, DeLong & Ross, 1 ♂.

97. *PALUDA* DeLong

Paluda DeLong (1937d, p. 233).

Fig. 244. The genus is related to *Cicadula* and can be distinguished by a dorsal blunt tooth on the posterior margin of each male plate; the apices of the pygofers terminate in bladelike structures that are produced the length of the segment beyond

its apex and directed dorsally and caudally. The aedeagus is different in type, composed of a broad basal portion and a short narrow apical process. The absence of black spots on the margin of the vertex also separates this genus from *Cicadula*.

Two species have been placed in this genus. One of them is known only from California; the other is chiefly eastern.

1. *Paluda mella* (Sanders & DeLong)

Thamnotettix mellus Sanders & DeLong (1917, p. 91).

Thamnotettix placidus Osborn (1905b, p. 536). Name preoccupied.

Thamnotettix placatus Baker (1924, p. 367). New name for *placidus*.

Length 5 mm. Small, orange yellow, with vertex broadly rounded, almost twice as wide between eyes as length at middle. Female seventh sternite with rather prominent lateral angles, between which the posterior margin is rather broadly excavated about one-third the distance to base; sides of excavated portion slightly convex, apex rather broad, with a slightly produced rounded tooth at center. Male plates, fig. 244, rather long, gradually and evenly narrowed to bluntly angled apices. Each style sinuately and gradually narrowed from a broad base to outwardly directed and bluntly pointed apex. Aedeagus broad on basal two-thirds, then rapidly narrowed to a slender apical third, which is directed dorsally. Apical portion of each pygofer narrowed into bladelike structure, which is strongly produced caudally and dorsally the length of the pygofer proper.

This species is northern in distribution and apparently inhabits the area occupied by the northern conifer forest. Although apparently having a more northern range than Illinois, it may at some time be found in the extreme northern part of the state.

98. *IDIODONUS* Ball

Idiodonus Ball (1936, p. 57).

Fig. 235B. Head narrower than pronotum, vertex short, blunt, obtusely rounded, and rounded to front. Elytra long, venation simple, with one crossvein. Female seventh sternite produced on posterior margin and with a slight median incision.

DeLong & Knull (1945) recorded 21 species and several varieties of this genus

for the United States. Only two are known to occur in Illinois.

KEY TO SPECIES

- Length 6.0 mm. or more; claval vein conspicuously pale in color.....1. *kennicotti*
 Length not over 5.75 mm.; reddish brown in color, claval vein not conspicuous.....2. *brittoni*

1. *Idiodonus kennicotti* (Uhler)

Jassus kennicotti Uhler (1863, p 161).

Length 6.0-6.5 mm. Fulvous, vertex dirty yellow, with red ocelli, two large, black spots between them; a pale transverse band at base fulvous. Vertex one-half longer at apex than next to eyes, twice as broad as long. Face dirty yellow. Pronotum with posterior margin and a median transverse band yellow. Elytral nervures lighter than disc, costal and apical areas yellowish hyaline; a broad conspicuous stripe on outer claval vein yellowish. Female seventh sternite, fig. 235*B*, with roundedly produced posterior margin slightly incised and keeled and with a brown spot at center. Male valve short and broad. Plates long, broad at bases, lateral margins concave, tips produced and pointed.

Usually found on oak and other shrubby plants or on tall herbaceous plants in shrubby areas, this species ranges from the eastern United States westward to British Columbia.

Illinois Records.—Many males and females, taken May 7 to October 1, are from Apple River Canyon State Park, Cobden, Dixon Springs, Dolson, Dubois, Elizabethtown, Galena, Golconda, Herod, Kankakee, Lawrenceville, Mason City, Muncie, Palos Park, Shawneetown, Temple Hill, Urbana, Vienna, and White Heath.

2. *Idiodonus brittoni* (Osborn)

Thamnotettix brittoni Osborn (1907, p. 166).

Length 5.0-5.75 mm. Reddish brown, vertex yellowish, ocelli red and with two black spots between ocelli. Vertex one-third longer at middle than next to eyes. Clavus of each elytron with pale stripe, veins pale, sutural line reddish. Males often golden tinted. Yellow markings absent. Female seventh sternite with posterior margin rounded, slightly notched at center. Male

valve short, plates concave on outer margins, apexes narrow.

Previously recorded from the eastern part of the United States, this species usually occurs on shrubs; it is not found in great abundance.

Illinois Records.—DUBOIS: Aug. 8, 1917, 1 ♀; Aug. 9, 1917, 1 ♀. ELIZABETHTOWN: May 22-24, 1932, Ross, Dozier, & Park, 1 ♀. GRAFTON: along river, June 26, 1934, DeLong & Ross, 1 ♂. KARNAK: Aug. 8, 1934, Ross, DeLong, & Mohr, 1 ♂, 1 ♀. MONTICELLO: June 11, 1934, 2 ♂. MUNCIE: Sept. 20, 1935, Frison & Mohr, 1 ♂. OAK LAWN: in lamp globe, Aug. 22, 1934, DeLong & Ross, 1 ♂. PULASKI: May 25, 1932, H. L. Dozier, 1 ♀. VIENNA: savanna grasses, June 14, 1934, DeLong & Ross, 1 ♀; July 29, 1934, DeLong & Ross, 1 ♀.

99. *COLLADONUS* Ball

Colladonus Ball (1936, p. 57).

Fig. 465. Head conical, much narrower than pronotum, longer and more pointed. Elytra appressed posteriorly. Female seventh sternite with a strap-shaped or spatulate median projection. Male plates together spoon shaped.

DeLong & Knoll (1945) listed 21 species and 3 varieties in this genus for the United States. Two species have been taken in Illinois, and at least one other may occur here.

KEY TO SPECIES

1. Vertex with two round black spots on margin; elytra black or dark brown, with a yellow saddle area.....2
 Vertex without black spots on margin; elytra paler in color.....1. *eburatus*
2. Female seventh sternite, fig. 234*B*, with rounded lateral lobes that are not notched.....2. *clitellarius*
 Female seventh sternite with lateral lobes decidedly notched posteriorly.....3. *furculatus*

1. *Colladonus eburatus* (Van Duzee)

Thamnotettix eburata Van Duzee (1889*a*, p. 10).

Length 6 mm. Paler in color than *clitellarius* but with the same general pattern. Vertex decidedly produced and bluntly angled, yellow without dark markings. Pronotum, scutellum, and elytra pale brown. Each clavus pale yellow, except anterior

fourth and apex; outer claval vein conspicuously dark brown and apex brownish. Female seventh sternite with broadly rounded lateral lobes; posterior margin deeply excavated on either side of a long

gola, Eldorado, Elizabethtown, Fox Lake, Fulton, Galena, Grafton, Grand Tower, Grays Lake, Havana, Iroquois, Kampsville, Kankakee, Karnak, Keithsburg, La Grange, Lima, Mahomet, Makanda, Meredosia,



Fig. 465.—*Colladonus clitellarius*.

median spatulate process. Male valve triangular, plates long, slightly and convexly rounded to pointed apices.

This is a northern species occurring in small numbers in wooded areas.

2. *Colladonus clitellarius* (Say)

Jassus clitellarius Say (1831, p. 309).

Length 5.0–5.5 mm. Brown, with yellow oval saddle spot involving clavus of each elytron, costal area yellowish. Vertex bright yellow, with two large round black spots on apex between ocelli; short and broad, one-fourth longer at middle than next to eyes. Pronotum with a broad brown band on anterior third. Female seventh sternite, fig. 234B, with posterior margin broadly excavated half way to base and with a median tooth produced beyond the lateral lobes. Male plates rather short, apices bluntly rounded.

Abundant and widely distributed in eastern and middle western states, this species apparently occurs on both shrubs and herbs.

Illinois Records.—Many males and females, taken May 19 to October 28, are from Algonquin, Alton, Amboy, Antioch, Apple River Canyon State Park, Atlas, Bradley, Byron, Cave in Rock, Champaign, Chemung, Des Plaines, Dixon, Dolson, Don-

Monticello, Mount Carmel, Muncie, New Holland, New Milford, Oak Lawn, Onarga, Oquawka, Oregon, Pike, Pulaski, Quincy, Round Lake, St. Anne, Savanna, Seymour, Shawneetown, Springfield, Starved Rock State Park, Urbana, Vienna, Volo, Warren, White Pines Forest State Park, Wilmington, and Zion.

3. *Colladonus furculatus* (Osborn)

Thamnotettix furculatus Osborn (1905a, p. 275).

Length 5 mm. Distinguished from *clitellarius* by the posteriorly notched lateral lobes of the seventh sternite of female. Vertex roundedly produced, yellow, with a pair of large black spots at apex. Posterior margin of vertex and anterior portion of pronotum between eyes brown. Scutellum and elytra brown. A pale transparent margin on costa, an oval spot on each clavus yellow. Male plates almost straight margined, acutely angled at apices.

This is usually considered a rather rare species and is found only in small numbers in wooded areas. It has previously been recorded from Pennsylvania and Ohio.

Illinois Record.—APPLE RIVER CANYON STATE PARK: Aug. 27, 1934, Frison & DeLong, 1 ♀.

100. *DAVISONIA* Dorst

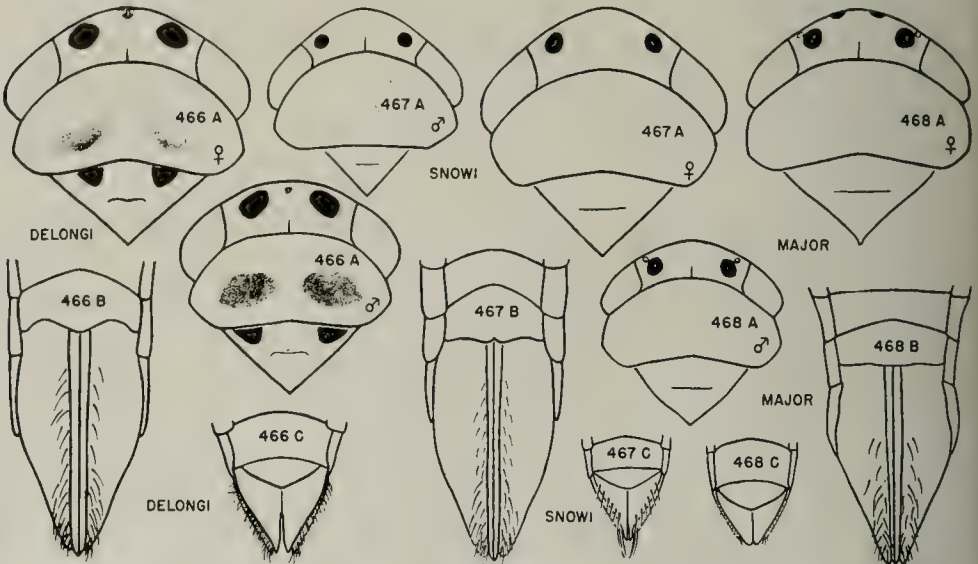
Davisonia Dorst (1937, p. 4).

Fig. 213. Vertex transverse and almost parallel margined, broadly rounded to front, front broad. Pronotum broad. Elytra long and broad, slightly narrowed apically, each with two antepical and four apical cells; posterior wings with three apical cells. Male pygofers without caudoventral lobes. Stem of connective twice as long as arms on internal genitalia.

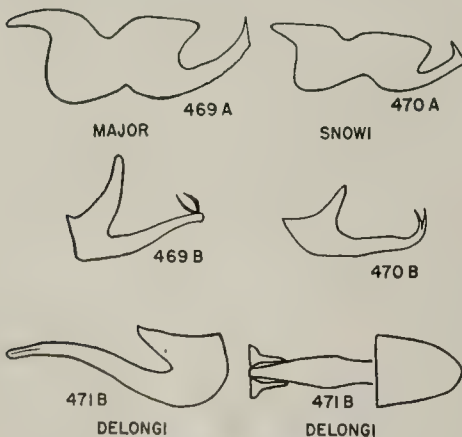
Four species are recorded by Dorst (1937) for the United States, and three of these have been taken in Illinois.

KEY TO SPECIES

1. Vertex almost parallel margined; length 4.5–7.0 mm. 2
Vertex, fig. 467, slightly but distinctly longer at middle than next to eyes; length 4.0–5.0 mm. 1. **snowi**
2. Female seventh sternite, fig. 468B, almost truncate; two small brown spots near apex of vertex, fig. 468A. 2. **major**



Figs. 466–468.—*Davisonia*. A, head and pronotum; B, female genitalia; C, male external genitalia. (After Dorst.)



Figs. 469–471.—*Davisonia*, male genitalia. A, style; B, aedeagus in lateral or ventral aspect. (After Dorst.)

Female seventh sternite, fig. 466B, with a broad produced median lobe; spot near apex of vertex, fig. 466A. 3. **delongi**

1. *Davisonia snowi* (Dorst)

Cicadula snowi Dorst (1931, p. 41).

Length 4–5 mm. Not as robust as *major*, with vertex more produced, bluntly angled. Yellowish, vertex, fig. 467A, with two black spots, one back of each ocellus; elytra whitish hyaline, nervures pale. Female seventh sternite, fig. 467B, almost truncate, with a median small shallow V-shaped notch. Male plates, fig. 467C, more elongate, apices slender, appearing attenuated. Male aedeagus, fig. 470B, terminating in two short finger-like processes compressed dorsoventrally and ending in sharp points. Styles as in fig. 470A.

Known only from *Salix*, this species is found in the middle western region of the United States and west to Montana and Colorado.

Illinois Record.—PIKE: Mississippi flood plain, June 28, 1934, DeLong & Ross, 1 ♀.

2. *Davisonia major* (Dorst)

Cicadula major Dorst (1931, p. 43).

Length 5–7 mm. Large and robust, yellow, with two large rounded spots on vertex, back of ocelli, fig. 468*A*, and often with two smaller proximal spots on the margin. Elytra often with grayish stripes. Vertex slightly longer at middle than next to eyes, broadly rounded on anterior margin and broadly rounding to front. Female seventh sternite, fig. 468*B*, almost truncate, posterior margin slightly produced at middle. Male plates, fig. 468*C*, short and rather broad, apexes bluntly angled. Aedeagus, fig. 469*B*, with two short curved processes near apex. Styles as in fig. 469*A*.

This species occurs on *Salix* in the eastern United States and west to Colorado.

Illinois Records.—Males and females, taken June 9 to August 8, are from Alton, Fulton, Grafton, Grand Tower, Havana, Kampsville, Kankakee, Metropolis, New Milford, Pike, Prophetstown, Quincy, Shawneetown, and Warsaw.

3. *Davisonia delongi* Dorst

Davisonia delongi Dorst (1937, p. 6).

Length 4.5–5.5 mm. Not as robust as *major*, but similarly marked. Vertex, fig. 466*A*, yellowish, with two large black spots near anterior margin and a smaller black or brown spot near apex; vertex almost parallel margined. Female seventh sternite, fig. 466*B*, with posterior margin emarginate on either side of a median broad slightly produced tooth; lateral angles produced. Male plates, fig. 466*C*, broad, triangular, apexes acutely pointed. Aedeagus, fig. 471*B*, large, bluntly pointed, with two small triangular plates along shaft at apex.

Occurring on *Salix*, this species is distributed in the eastern United States through the Middle West to New Mexico.

Illinois Records.—Many males and females, taken June 10 to August 24, are from Algonquin, Apple River Canyon State Park, Centerville, Champaign, Kankakee, Ma-

homet, Metropolis, Monticello, Mount Carmel, New Milford, Urbana, Waukegan, and West Union.

101. *SONRONIUS* Dorst

Sonronius Dorst (1937, p. 9).

Wing venation as in *Davisonia* and *Macrostoteles*. Each male pygofer with a slight caudoventral notch. Male genital connective stem one and one-half times as long as arms.

Dorst (1937) records three species of this genus, only one of which is known to occur in Illinois.

1. *Sonronius clavatus* (DeLong & Davidson)

Cicadula clavata DeLong & Davidson (1934, p. 223).

Length 4 mm. Golden yellow, marked with black. Vertex bluntly produced, with a pair of large round black spots just above margin. Pronotum unmarked. Elytra with each clavus dark brown, apical third dark, smoky to brown. Face yellow. Female seventh sternite with posterior margin roundedly produced, almost truncate. Male plates triangular, produced into elongate upturned apices.

This species is very strikingly marked. Nothing is known concerning its biology or food plant. It was described from a small series of specimens from New Jersey and it may represent an importation. It has more recently been found in northern Illinois, but the record is based upon a single specimen.

Illinois Record.—ANTIOCH: July 5–7, 1932, 1 ♂.

102. *MACROSTEELES* Fieber

Macrosteles Fieber (1866, p. 504).

Fig. 245*B*. Vertex longer at middle than next to eyes, bluntly angled. Pronotum short. Elytra long, exceeding the abdomen, the two overlapping apically, each with a distinct appendix, two anteapical cells, and four apical cells. Each hind wing with three closed apical cells. Male plate with attenuated finger-like process. Male pygofers with distinct caudoventral processes. Male aedeagus with two finger-like apical processes. Connective with stem about equal to arms in length.

Sixteen species of *Macrosteles* are recorded by Dorst (1937) for the United States, and six of these are known to occur in Illinois.

KEY TO SPECIES

1. Length not more than 2.5 mm. **1. *potoria***
- Length more than 3.0 mm. **2**
2. Spots on vertex, fig. 477*A*, convergent, not distinct. **2. *slossoni***
- Spots on vertex distinct, usually not contiguous. **3**
3. Vertex, fig. 476*A*, with three distinct pairs of spots arranged in two rows. **3. *divisa***
- Vertex with one or two pairs of spots in addition to spots next to eyes. **4**
4. Vertex, fig. 475*A*, with a pair of spots just back of ocelli and none between ocelli on margin. **4. *binotata***
- Vertex with a pair of spots back of ocelli and another pair between ocelli on margin. **5**
5. A pair of spots between ocelli and eyes, fig. 472*A*. **5. *lepida***
- Without spots next to eyes, fig. 473*A*. **6. *variata***

1. *Macrosteles potoria* (Ball)

Cicadula potoria Ball (1900c, p. 346).

Length 2.0–2.5 mm. Very small, black, with a sharply angled vertex. Vertex, pronotum, and scutellum heavily marked with black. Vertex, fig. 474*A*, usually black, with an oblique white spot on either side of a central white stripe, which terminates in a white posterior portion; often entire vertex black. Elytra subhyaline, nervures dark. Female seventh sternite, fig. 474*B*, slightly emarginate at middle. Male plates, fig. 474*C*, very short, apices sharply pointed and attenuate. Aedeagus, fig. 480*B*, terminating in two slender processes that are crossed and directed laterally. Styles as in fig. 480*C*.

A common species on wet areas of ponds and lagoons on a fine mat of *Eleocharis*, *potoria* is recorded principally from the eastern states.

Illinois Record.—BEACH: July 25, 1934, Frison & DeLong, 4♂, 12♀.

2. *Macrosteles slossoni* (Van Duzee)

Cicadula slossoni Van Duzee (1893, p. 281).

Length 3.5–4.0 mm. Smaller than *divisa* and with darker markings. Vertex, fig. 477*A*, bluntly angled, with three pairs of black spots and another next to either eye

usually converging into a curiously shaped black picture. Pronotum and scutellum variously marked with black. Female seventh sternite, fig. 477*B*, truncate, posterior margin slightly sinuate. Male plates, fig. 477*C*, triangular, with pointed attenuated apices, which are slightly divergent. Aedeagus, figs. 478*A*, 478*B*, similar to that of *divisa*, terminating in two finger-like processes, which are directed caudally. Style as in fig. 478*C*.

A common transcontinental species in marshes and at the margins of swamps, *slossoni* occurs on small vegetation associated with species of *Eleocharis*.

Illinois Record.—McHENRY: July 27, 1934, DeLong & Ross, 4♀.

3. *Macrosteles divisa* (Uhler)

Jassus divisus Uhler (1877, p. 472).

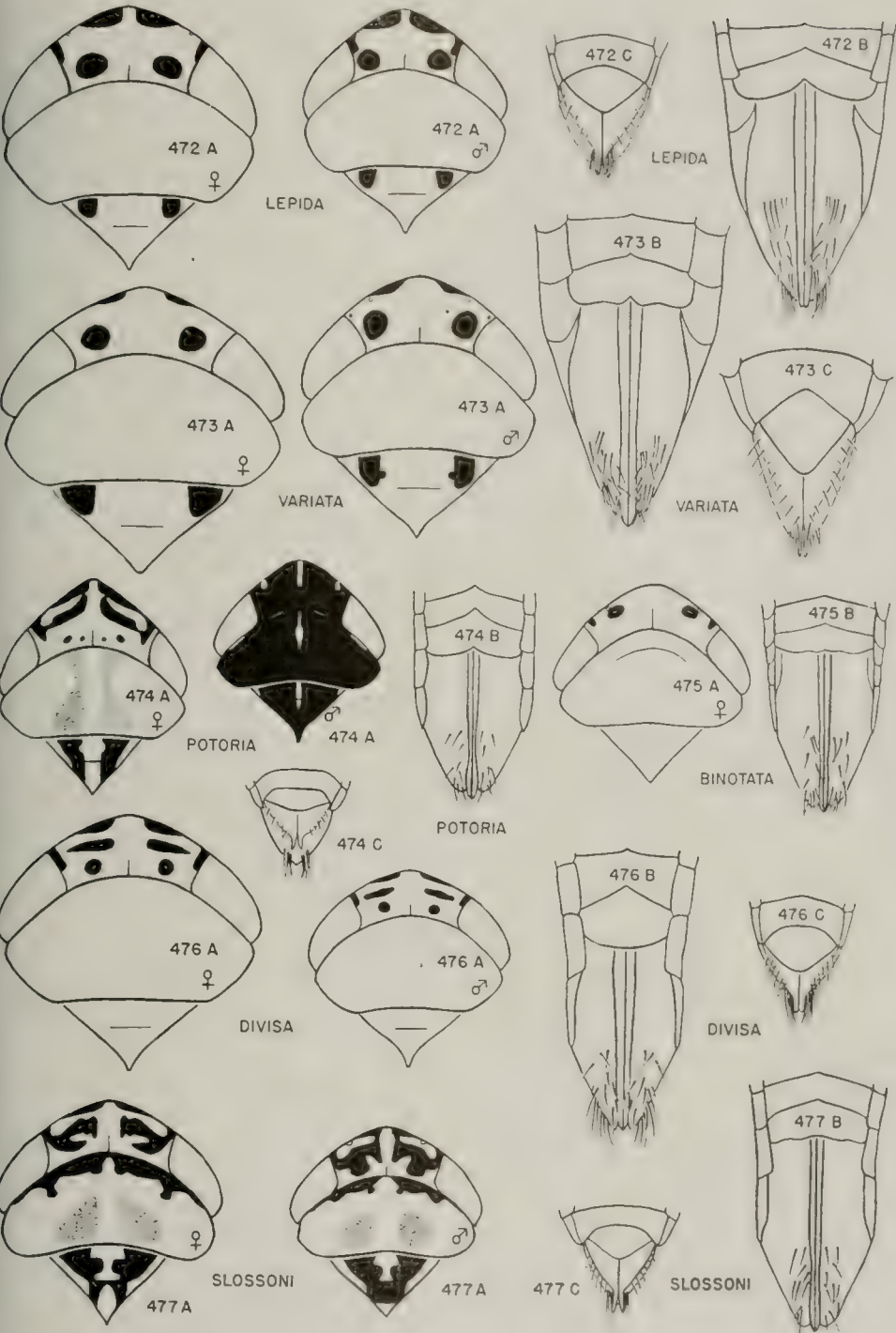
Cicada sexnotata Fallen (1806, p. 34). (American records cited in error.)

Cicadula quadrilineatus Forbes (1885, p. 68).

Length 3.5–4.5 mm. Greenish yellow, with three pairs of spots or transverse dashes on vertex, fig. 476*A*, the pair of spots on margin and the pair on disc of vertex usually transverse, the posterior pair usually round. There is usually a spot next to each eye. Vertex bluntly produced and rounded to front. Female seventh sternite, fig. 476*B*, with posterior margin truncate or roundedly produced. Male plates, fig. 476*C*, short, triangular, apices acutely pointed and attenuated. Aedeagus, figs. 481*A*, 481*B*, terminating in two finger-like processes that are produced caudally and pointed at apices. Styles as in fig. 481*C*.

This species is the most common and important of the genus and is common upon many economic plants throughout the United States. It is variable in size and intensity of color markings.

Illinois Records.—Many males and females, taken April 15 to October 30, are from Algonquin, Alsip, Alton, Alto Pass, Antioch, Apple River Canyon State Park, Aurora, Barry, Beach, Bradley, Buda, Bushnell, Cache, Cairo, Carbondale, Carman, Cedar Lake, Champaign, Chemung, Decatur, Des Plaines, Dixon Springs, Du Bois, East St. Louis, Evergreen Park, Fox Lake, Fulton, Geff, Gibson City, Grafton, Grays Lake, Harrisburg, Harvard, Havana, Herod, Homer, Horseshoe Lake, Ingleside,



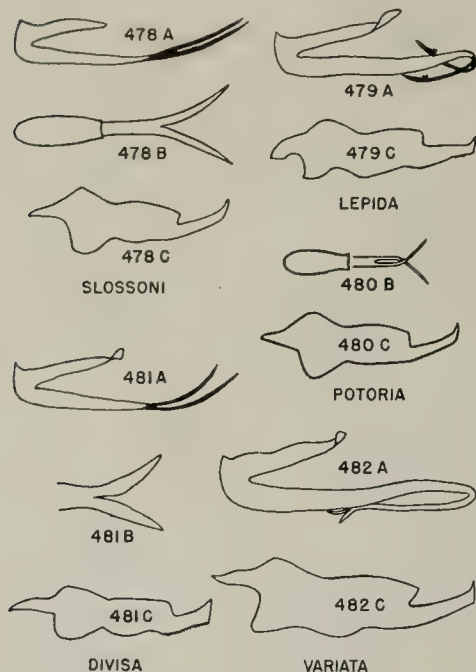
Figs. 472-477.—*Macrostelus*. A, head and pronotum; B, female genitalia; C, male external genitalia. (After Dorst.)

Kampsville, Kankakee, Karnak, Kirkwood, Lake Villa, Lawrenceville, L'Erable, Lima, Luther, Mahomet, Manteno, McHenry, Meredosia, Metropolis, Mokena, Momence, Monmouth, Monticello, Mount Carmel, Mount Sterling, New Holland, Niota,

seventh sternite, fig. 475B, with posterior margin slightly sinuate, almost truncate.

This species is recorded from Ontario, Maine, and Illinois. Only one female has been taken in this state.

Illinois Record.—WAUKEGAN: July 6, 1932, 1 ♀.



Figs. 478-482.—*Macrosteles*, male genitalia. A, lateral aspect of aedeagus; B, ventral aspect of aedeagus; C, style.

Normal, Norris City, Oak Lawn, Oakwood, Oquawka, Ottawa, Palos Park, Pankeyville, Pecatonica, Pike, Port Byron, Princeton, Putnam, Quincy, Quiver Lake, Rantoul, Rock Island, St. Anne, Savanna, Shawneetown, Sheffield, Sparta, Springfield, Spring Valley, Starved Rock State Park, Summit, Thomson, Topeka, Urbana, Ursa, Vandalia, Vienna, Volo, Wauconda, Waukegan, and Zion.

4. *Macrosteles binotata* (Sahlberg)

Limotettix binotata Sahlberg (1871, p. 242).
Cicadula suffusa Osborn (1915, p. 146).

Length 5 mm. Similar to *variata*; vertex, fig. 475A, bluntly and angularly produced. Vertex and frons orange yellow, vertex with two black spots just above ocelli and a smaller spot next to each eye. Female

5. *Macrosteles lepida* (Van Duzee)

Cicadula lepida Van Duzee (1894a, p. 139).

Length 4-5 mm. Vertex, fig. 472A, more angularly produced than in *variata*, with markings similar except for an additional spot next to each eye. Vertex obtusely angled, yellowish or yellowish green, a pair of large round black spots near posterior margin, two large black proximal spots on anterior margin, and a black spot between ocellus and compound eye on each side. Elytra whitish hyaline, often smoky on basal portion. Female seventh sternite, fig. 472B, with posterior margin convexly rounded on either side of a median broad shallow notch. Male plates, fig. 472C, rather short, apices attenuated and appressed. Aedeagus, fig. 479A, similar to that of *variata*, terminating in two finger-like processes, each recurved beneath for one-third the length of shaft; apical portion armed with teeth. Styles as in fig. 479C.

Rather common in moist areas, especially in woodland marshy habitats, *lepida* occurs in the eastern part of the United States and in the Middle West.

Illinois Records.—Males and females, taken May 7 to August 25, are from Algonquin, Champaign, Dolson, Dubois, East Cape Girardeau, Havana, Karnak, Paxton, Urbana, Vienna, Volo, Wauconda, and Zion.

6. *Macrosteles variata* (Fallen)

Cicada variata Fallen (1806, p. 34).
Jassus fumatus Herrick-Schaeffer (1838, fasc. 153, p. 5).

Length 5-6 mm. Yellowish or yellowish green, vertex, fig. 473A, with two large black spots on anterior margin and two large black spots near posterior margin; vertex bluntly and angularly produced. Elytra whitish hyaline, often smoky. Female seventh sternite, fig. 473B, truncate, with a V-shaped notch at center. Male plates, fig. 473C, with long attenuate apices. Aede-

gus, fig. 482*A*, terminating in two finger-like processes that are about one-half the length of aedeagus shaft and recurved under shaft. Style as in fig. 482*C*.

A common species on *Impatiens* in moist woodland areas, *variata* is widely distributed in the East and Middle West, and to Colorado and New Mexico.

Illinois Records.—Many males and females, taken May 18 to October 16, are from Algonquin, Alton, Antioch, Apple River Canyon State Park, Beach, Charleston, Chemung, Chicago, Dixon, Dolson, Dubois, Elizabeth, Elizabethtown, Elmira, Fern Cliff, Fox Lake, Freeport, Grinnell, Homer, Karnak, Meredosia, Metropolis, Monticello, Mounds, Oak Lawn, Oquawka, Paxton, St. Joseph, Savanna, Shawneetown, Temple Hill, Urbana, Volo, Wauconda, White Heath, Wilmington, and Zion.

Subfamily JASSINAE

This group is characterized by a vertex that is comparatively narrow anteriorly between the eyes but distinctly broadened posteriorly behind the eyes. The vertex is raised between the eyes like a broad keel. The forewing is broad and broadly rounded at apex. Frons long and nearly parallel sided.

Two North American genera belong to this subfamily.

KEY TO GENERA

- Face narrow, sides inflated below eyes, and with frons, fig. 13, about three times as long as wide; ocelli not visible between eyes; end of abdomen exposed beyond elytra, fig. 485 **104. *Tinobregmus***
 Face broad, sides narrowed below eye, and with frons, fig. 14, about twice as long as wide; ocelli visible between eyes; elytra covering abdomen. **103. *Jassus***

103. *JASSUS* Fabricius

Jassus Fabricius (1803, p. 85).

Figs. 14, 24, 486. Head narrower than pronotum, vertex quadrate, broadly curved anteriorly, only slightly produced before anterior margins of eyes; eyes large, not widely separated. Pronotum very short, emarginate posteriorly. Scutellum large, very wide at base. Elytra broad, rather short, apexes broadly rounded.

Four of the five species recorded for the

United States by Lawson (1927) are found in the eastern part of this country, and two of these have been taken in Illinois, while a third species may occur here.

KEY TO SPECIES

1. Color dark or transversely banded, but clytra without lighter costal margins; aedeagus bent or hooked at tip; female seventh sternite variable. 2



Female seventh sternite

Fig. 483.—*Jassus melanotus*.

Fig. 484.—*Jassus olitorius*.

Color dark, costal margins pale; female seventh sternite, fig. 483, with shallow apical indentation; apex of lower portion of aedeagus blunt, not bent.

- **1. *melanotus***
 2. Males dark or usually uniformly colored, females usually with two distinct transverse bands on each elytron; female seventh sternite, fig. 484, with a narrow median incision at produced apex
 **2. *olitorius***
 Unicolorous or with veins darker, each elytron with not more than one transverse band; female seventh sternite with a faint notch at apex. ... **3. *borealis***

1. *Jassus melanotus* Spangberg

Jassus melanotus Spangberg (1878*a*, p. 19).

Length of male 6.0 mm., female 7.5 mm. Robust; pronotum, scutellum, and elytra dark brown to black, without pale transverse bands in female but with each apex and costal margin pale, often conspicuously yellow. Vertex light greenish yellow, median longitudinal line brown; eyes dark. Face greenish, with sides showing faint fuscous arcs. Venter yellowish, marked with black. Female seventh sternite, fig. 483, with posterior margin bisinuate, forming three lobes, the central one larger, longer than lateral lobes and keeled at center. Male plates long and narrow. Ventral portion of aedeagus with apical portion bent anteriorly and with an apical spine.

This species has been collected in low

marshy areas in the willow-sedge habitat. It occurs in the eastern and middle western states. The food plant is not known.

Illinois Records.—Males and females, taken June 27 to August 28, are from Alto Pass, Apple River Canyon State Park, Chemung, Fountain Bluff, Golconda, Grand Tower, Jonesboro, Karnak, Shawneetown, Vienna, Warren, White Pines Forest State Park, and Wolf Lake.

2. *Jassus olitorius* Say

Jassus olitorius Say (1831, p. 310).

Jassus subbifasciatus Say (1831, p. 310).

Jassus fuscipennis Spangberg (1878a, p. 20).

Fig. 486. Length 6.0–7.5 mm. Female vertex dull yellow, with brown ocelli and markings; pronotum light brown, a pale median stripe bordered with a dark stripe on either side; scutellum with the basal angles and two spots on disc black; elytra brown, nervures black, interrupted twice by light transverse bands. Male with pronotum, scutellum, and elytra darker than in female, without transverse bands on elytra. Vertex obtusely rounded, about as long as basal width. Female seventh sternite, fig. 484, twice as long as preceding, strongly produced and keeled at middle. Male plates long and narrow. Lower portion of aedeagus blunt at apex, with an apical and a ventrocaudal spine.

Common on oak, sassafras, and similar shrubs, *olitorius* occurs in the East and Middle West, and southwest to Arizona.

Illinois Records.—Many males and females, taken June 21 to October 1, are from Aldridge, Alto Pass, Apple River Canyon State Park, Ashley, Byron, Carbondale, Charleston, Dixon Springs, Dolson, Dongola, Dubois, Elizabethtown, Fountain Bluff, Golconda, Grand Tower, Herod, Jonesboro, Kampsville, Kankakee, Karnak, La Rue, Lawrenceville, Makanda, Marshall, Metropolis, Normal, Oakwood, Olive Branch, Onarga, Pekin, Pulaski, Quincy, River Forest, Rock Island, St. Joseph, Shawneetown, Sugar Grove, Sumner, Temple Hill, Urbana, Vienna, Warren, Watson, White Heath, and Wolf Lake.

3. *Jassus borealis* Spangberg

Jassus borealis Spangberg (1879, p. 24).

Length 5.5–8.0 mm. Rusty brown to dark brown, vertex usually yellow, with two

darker spots posterior to middle. Basal angles of scutellum sometimes black. Elytra usually unicolorous, sometimes with paler areas on each clavus and across apexes of anteapical cells; apexes of elytra sometimes tinted with fuscous. Female seventh sternite with distinct lateral angles between which the posterior margin is rather strongly and broadly produced with a faint notch at apex. Male plates long, with rounded apexes. Aedeagus similar to that of *olitorius* but ventral process slightly more enlarged at apex.

This species is known only from South Carolina, Georgia, and Florida.

104. *TINOBREGMUS* Van Duzee

Tinobregmus Van Duzee (1894b, p. 213).

Figs. 13, 485. Head narrow, short, conical, vertex narrow between eyes, widened anteriorly, expanded behind the eyes; ocelli on vertex near apex; eyes large. Pronotum short, wider than head. Elytra short, extending to middle of abdomen, each with five apical areoles, the outer one much larger. Posterior wings rudimentary. The very small scutellum and elongated face distinguish this from most other genera of Nearctic Cicadellidae.

Lawson (1932a) records four species and one variety of this genus for the United States; only one of these is known to occur in Illinois.

1. *Tinobregmus viridescens* DeLong

Tinobregmus viridescens DeLong (1916, p. 92).

Fig. 485. Length of male 4.0 mm., female 6.5 mm. Elytra yellowish green; a broad band at each apex, and irregular longitudinal lines running forward from the apex black. Male vertex black; sutures and a triangular area between vertex and eye and the margin of the occiput pale; pronotum greenish yellow. Elytra of male and female similarly marked. Female seventh sternite with a slightly sinuate posterior margin. Male valve and almost all of plates concealed in concavity of last sternite. Pygofers large, curving over the plates.

This species occurs on rank herbaceous growth, especially in open woodland in the middle western and eastern states.

Illinois Records.—ASHLEY: July 6, 1889, Marten, 1 ♂. DUBOIS: June 22, 1905,

1 ♀; sweeping from grass, July 2, 1909, 2 ♂, 1 ♀; Aug. 9, 1917, 1 ♂, 6 ♀; Aug. 18, 1917, 3 ♂. METROPOLIS: Aug. 19, 1891, Shiga, 1 ♀. ROSICLARE: July 5, 1935, Frison & Mohr,

Oman (1931) and Knull (1942) have recorded 21 species and several subspecies of *Neocoelidia* for the United States, all of which are western or southwestern in dis-



Fig. 485.—*Tinobregmus viridescens*.

1 ♀. SHAWNEETOWN: June 23, 1936, DeLong & Ross, 1 ♂; June 27, 1936, DeLong & Mohr, 2 ♂. VIENNA: June 14, 1934, DeLong & Ross, 1 nymph; July 29, 1934, DeLong & Ross, 2 ♂, 7 ♀.

tribution. One species, *tumidifrons*, has extended its range into the eastern states.

1. *Neocoelidia tumidifrons* Gillette & Baker

Neocoelidia tumidifrons Gillette & Baker (1895, p. 104).

Fig. 487. Length 4 mm. Pale yellow or pale greenish, robust, usually with a black spot in each basal angle of scutellum. Vertex and face often washed with orange. Vertex curved to front, one-half longer at middle than next to eyes. Pronotum three times as broad as long. Elytra broad and rather short, reaching just to tip of abdomen. Female seventh sternite with posterior margin broadly excavated and with a short median tooth; lateral angles slightly rounded. Male valve broadly triangular. Plates more than one-half longer than valve, gradually tapered from bases to pointed apices, exceeded by pygofers at apices. Pygofers visible at the sides of plates to bases.

Common in moist wooded areas, especially where herbaceous growth is abundant, this species has been found in the eastern states and west to Texas and Colorado.

Illinois Records.—Males and females, taken May 9 to August 23, are from Alto Pass, Dongola, Dubois, Evergreen Park,

Subfamily NEOCOELIDIINAE

This group contains two Nearctic genera characterized by a raised vertex above and in front of the eyes. They are similar to the Jassinae in this feature, but the frons is expanded dorsad and is not as long and not as nearly parallel as in the Jassinae.

KEY TO GENERA

Clypeus with a distinct tubercle 106. *Paracoelidia*
Clypeus not tuberculate 105. *Neocoelidia*

105. *NEOCOELIDIA* Gillette & Baker

Neocoelidia Gillette & Baker (1895, p. 103).

Head narrower than pronotum, short, obtusely conical. Front broad, almost parallel, antennae long. Pronotum short and broad, anterior and posterior margins nearly parallel. Scutellum large. Elytra variable in length, first sector branched once on the apical two-thirds with four apical cells.

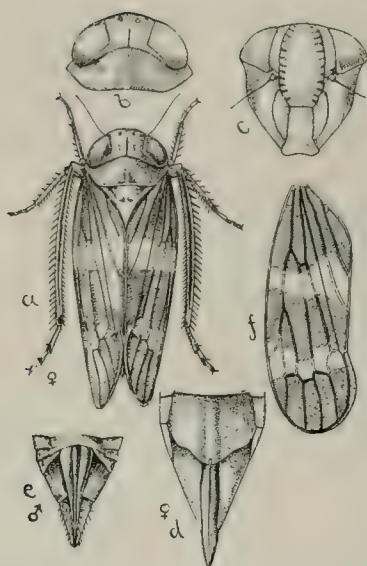


Fig. 486.—*Jassus olitorius*: a, adult; b, head and pronotum; c, face; d, female genitalia; e, male genitalia; f, elytron. (From Osborn.)

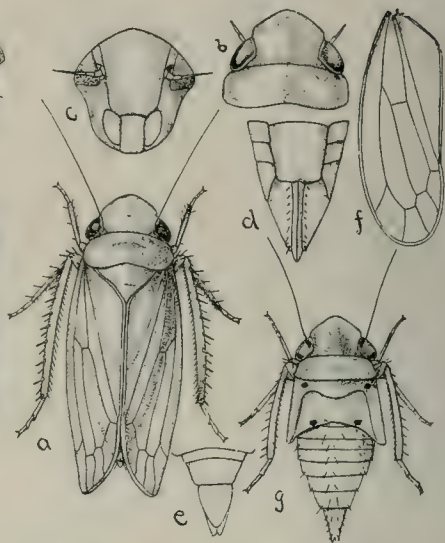


Fig. 487.—*Neocoelidia tumidifrons*: a, adult; b, head and pronotum; c, face; d, female genitalia; e, male genitalia; f, elytron; g, nymph.

Jonesboro, Karnak, Oak Lawn, Oakwood, Olive Branch, Pankeyville, Shawneetown, Vienna, and Wauconda.

106. *PARACOELIDIA* Baker

Paracoelidia Baker (1898f, p. 292).

Very similar to *Neocoelidia*, but with a decided tubercle on clypeus. Wings always long and narrow.

Only one of the three Nearctic species may occur in Illinois. The others are known only from Arizona.

1. *Paracoelidia tuberculata* Baker

Paracoelidia tuberculata Baker (1898f, p. 292).

Length 5 mm. Slender, elongate, similar in general appearance to the western species of *Neocoelidia*, but with a tubercle on the clypeus. Vertex produced, subangulate. Color yellowish, elytra subhyaline, a smoky stripe along the inner margins, and apexes smoky. Female seventh sternite truncate. Male valve long, angled, tapering. Male plates short, apexes obtuse.

Although common on pine in various areas of the eastern and southern United States, *tuberculata* has not been taken in Illinois. Eventually it may be found here.

Subfamily BALCLUTHINAE

The two anteapical cells of the forewing and three apical cells of the hind wing will easily separate the members of this group from other subfamilies, except some long-winged forms of normally short-winged Athysaninae.

Representatives of two genera belonging to this group occur in Illinois.

KEY TO GENERA

- Head narrower than pronotum, somewhat angularly produced, fig. 28. 107. *Balclutha*
 Head wider than pronotum, vertex not produced, broadly rounded, fig. 25. 108. *Nesosteles*

107. *BALCLUTHA* Kirkaldy

Gnathodus Fieber (1866, p. 505). Name pre-occupied.

Balclutha Kirkaldy (1900, p. 243). New name. *Eugnathodus* Baker (1903, p. 1).

Fig. 28. Head narrower than pronotum, vertex broadly rounded to bluntly and angularly produced. Each elytron with inner sector not forked, forming two anteapical cells. Aedeagus usually enlarged at base but not forming a dorsally directed process at anterior end.

Davidson & DeLong (1935) recorded

six species and two varieties for the United States, of which three species and the two varieties occur in Illinois. The other species are western.

KEY TO SPECIES

1. Vertex broadly rounded; aedeagus, fig. 489A, short, apex curved caudally and dorsally but not anteriorly.....

1. *abdominalis*

- Vertex bluntly angled; aedeagus longer, directed anteriorly at apex and sometimes extending into preceding segment.....

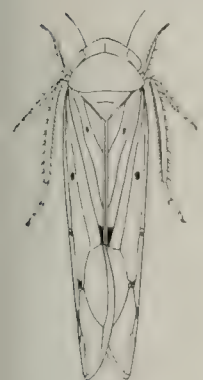


Fig. 488.—*Balclutha punctata*. (From Osborn.)

2. Aedeagus, fig. 489B, abruptly narrowed near base to a long and slender portion, which extends to posterior margin of preceding segment.....
3. Aedeagus, fig. 489C, shorter, basal portion more gradually narrowed to apical portion, which extends anteriorly only about half way to posterior margin of preceding segment; dorsum marked with brown.....
2. *punctata*
3. Color yellowish, sometimes washed with pale green.....
3. *impicta*
- Color usually dark green, or if pale then marked with black or brown.....
4. Color dark green, veins conspicuously green or rugose.....
4. *impicta* var. *osborni*
- Color yellowish or greenish, mottled with dark green or black.....
5. *impicta* var. *maculata*

1. *Balclutha abdominalis* (Van Duzee)

Gnathodus abdominalis Van Duzee (1892b, p. 113).

Length 3 mm. Dull yellow, ocelli dark; vertex bluntly rounded, a little more than twice as wide as median length, produced more than one-half its length before anterior margins of the eyes. Pronotum with prominent lateral angles. Aedeagus in lateral view, fig. 489A, with a basal enlargement extending dorsally; apical portion gradually tapering to a dorsally directed tip. Styles with

thick blunt apical processes. Connective thick at base, with a rather narrow incision. Apex enlarged and slightly indented at middle.

This is a common transcontinental species which, in Illinois, occurs on herbaceous growth.

Illinois Records.—Many males and females, taken April 21 to November 15, are from Algonquin, Alton, Alto Pass, Anna, Apple River Canyon State Park, Beach, Brownfield, Cave in Rock, Champaign, Dixon, Dixon Springs, Dolson, Dongola, Effingham, Eichorn, Elizabethtown, Evergreen Park, Farina, Fulton, Geff, Golconda, Grafton, Hanover, Havana, Herod, Ingle-side, Justice, Kampsville, Monticello, Muncie, Newton, Norris City, Oakwood, Oquawka, Oregon, Pike, Port Byron, Princeton, Pulaski, Rock Island, St. Anne, Savanna, Savoy, Shawneetown, Springfield, Starved Rock State Park, Urbana, Vienna, Volo, Wauconda, White Heath, and Zion.

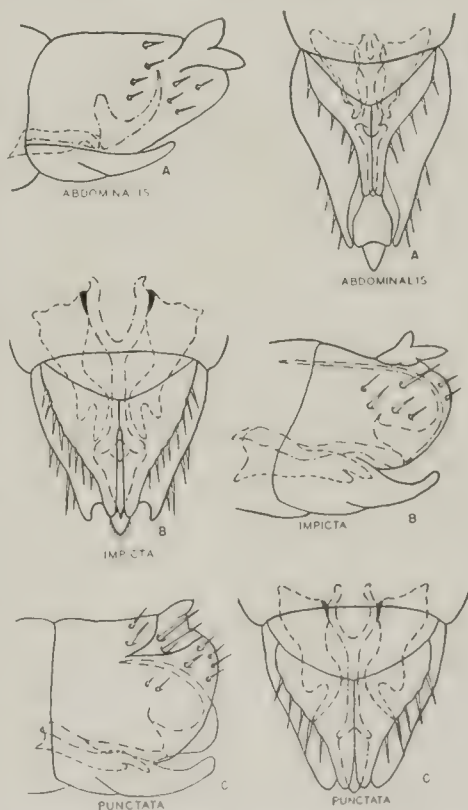


Fig. 489.—*Balclutha*, male genitalia. A—C, ventral and lateral aspects.

2. *Balclutha punctata* (Thunberg)

Cicada punctata Thunberg (1784, p. 21).

Gnathodus confusus Gillette & Baker (1895, p. 104).

Gnathodus occidentalis Baker (1896a, p. 41).

Gnathodus livingstoni Baker (1896a, p. 42).

Fig. 488. Length 3.5–4.0 mm. Color variable from gray or pale yellow to green and with markings variable or absent. The well-marked specimen with a somewhat reddish broken transverse band across vertex; mottlings on anterior portion of pronotum and median longitudinal line of pronotum, and basal angles and median line on scutellum reddish or brown. Elytra frequently with veins ferruginous or brown; inner portion of each clavus and a broken oblique band extending almost to costa brown; tip of clavus, spot on disc, also spots on posterior portions of anteapical cells, and portions of outer and inner apical cells brown. Vertex bluntly angled, almost parallel margined, nearly four times as wide between eyes as median length, produced almost its entire length before anterior margins of the eyes.

Aedeagus in lateral view, fig. 489C, gradually tapering from a broad elongated basal portion to a slender apical portion that is pointed and curves dorsally, then anteriorly, the apex reaching the middle of the last segment or a little farther cephalad. Apex of connective terminating in two rather narrow divergent processes.

A common species in Illinois, *punctata* ranges from the Middle West to British Columbia.

Illinois Records.—Many males and females, taken March 26 to November 12, are from Algonquin, Alto Pass, Amboy, Apple River Canyon State Park, Beach, Chemung, Danville, Dubois, Effingham, Fountain Bluff, Herod, Hopedale, Lake Villa, Mahomet, Monticello, Muncie, Oakwood, Ozark, Palos Park, Rock Island, Urbana, Volo, White Heath, and Zion.

3. *Balclutha impicta* (Van Duzee)

Gnathodus impictus Van Duzee (1892b, p. 113).

Length 3.5 mm. Yellow, tinged with green. Vertex bluntly angled, conspicuously narrower than pronotum, more than three times as wide as median length, produced two-thirds its length before anterior mar-

gins of the eyes. Aedeagus in lateral view, fig. 489B, enlarged at base, apical portion long and narrow, extending dorsally, then directed anteriorly along dorsal wall into preceding abdominal segment. Styles deeply notched at apexes forming long curved inner finger-like processes. Connective widely and deeply notched at base, forming a pair of widely separated curved processes. Apex deeply notched so as to form two rounded divergent tips.

A very common species in Illinois, *impicta* is found in the eastern states and west to Washington.

Illinois Records.—Many males and females, taken May 10 to September 20, are from Algonquin, Antioch, Apple River Canyon State Park, Atlas, Beach, Buckley, Buda, Cairo, Cave in Rock, Champaign, Chemung, Danville, Dixon Springs, Dolson, Dongola, Dubois, Eichorn, Elizabeth, Elizabethtown, Farina, Fourth Lake, Grafton, Havana, Herod, Justice, Kampsville, Karnak, La Grange, Lake Villa, Macomb, Monticello, Muncie, New Milford, Newton, Niota, Norris City, Oakwood, Oregon, Palos Park, Pike, Port Byron, Rock Island, Round Lake, St. Anne, Savanna, Seymour, Shawneetown, Springfield, Starved Rock State Park, Temple Hill, Urbana, Ursa, Vienna, Volo, Warsaw, Wauconda, White Heath, White Pines Forest State Park, Wilmington, and Zion.

4. *Balclutha impicta* var. *osborni*

Van Duzee

Gnathodus viridis Osborn (1905b, p. 541).

Name preoccupied.

Balclutha osborni Van Duzee (1916, p. 75).

New name.

Length 3.5–4.0 mm. Size and form of *impicta*, with the same type of genital characters. Color yellowish, tinted with green. Venation dark green, rugose.

This form has been recorded from the eastern states and Canada, and a few specimens have been taken in Illinois.

Illinois Records.—APPLE RIVER CANYON STATE PARK: July 11, 1934, DeLong & Ross, 2 ♂, 2 ♀. DONGOLA: Aug. 23, 1916, 1 ♂, 1 ♀. JONESBORO: State Forest, July 31, 1934, DeLong & Mohr, 1 ♂. URBANA: July 21, 1889, C. A. Hart, 1 ♂. VIENNA: June 14, 1934, DeLong & Ross, 2 ♂. VOLO: July 27, 1934, DeLong & Ross, 1 ♂.

5. *Balclutha impicta* var. *maculata*

Davidson & DeLong

Balclutha impicta var. *maculata* Davidson & DeLong (1935, p. 101).

Length 3.5 mm. Coloration same as in well-marked specimens of *punctata*, but with size and genitalia of *impicta*. Markings frequently very heavy, with vertex, pronotum, and entire elytra heavily mottled with brown; often bright green, with heavy markings on posterior portion of pronotum; elytra with scattered spots on each clavus, a large spot at apex, and three or four conspicuous spots on central portion brown. Degree and intensity of spotting vary.

This variety is recorded from the eastern states and west to Wisconsin and Illinois.

Illinois Records.—Many males and females, taken April 5 to November 25, are from Algonquin, Apple River Canyon State Park, Carmi, Champaign, Dolson, Dongola, Duncans Mills, Fulton, Golconda, Muncie, Newton, Port Byron, Pulaski, Rock Island, St. Joseph, Springfield, Starved Rock State Park, Urbana, Volo, Warren, White Heath, and White Pines Forest State Park.

108. *NESOSTELES* Kirkaldy*Nesosteles* Kirkaldy (1906, p. 343).*Agellus* Davidson & DeLong (1933, p. 210).

Fig. 25. Vertex broadly rounded and scarcely produced before the anterior margins of the eyes, anterior and posterior margins almost parallel; head slightly broader than pronotum, lateral posterior angles of pronotum not wider than vertex. General venation as in *Balclutha*, with inner sector of elytron not forked, two anteapical cells being produced. Aedeagus with dorsobasal protruding processes. In *Balclutha* the basal portion is enlarged and may extend dorsally but without finger-like processes.

Davidson & DeLong (1935) record eight species and one variety in the United States, but only one species and the only variety in the genus are known to occur in Illinois.

1. *Nesosteles neglecta* (DeLong & Davidson)*Eugnathodus neglecta* DeLong & Davidson (1933, p. 55).

Length 3.5 mm. Pale to dark brown in color, often with rather conspicuous mark-

ings on vertex, pronotum, and scutellum. Elytra smoky to white. Vertex broadly rounded, almost parallel margined, and about four times as wide as long. Female seventh sternite almost truncate, posterior margin slightly emarginate on either side of a central slightly produced inconspicuous median tooth. Male plates triangular, about half as wide at base as long. Aedeagus in lateral view rather heavy at base, anterior process extending dorsally, arising not far from the point of union with the connective; body of aedeagus extending caudally, tapered, and extending dorsally and slightly posteriorly; terminal portion about twice the length of the anterior process.

This species is common and widely distributed in the United States and is found throughout Illinois.

Illinois Records.—Many males and females, taken May 4 to October 11, are from Alton, Apple River Canyon State Park, Beach, Billett, Carman, Collinsville, Evergreen Park, Fox Lake, Fulton, Galena, Hanover, Havana, Herod, Lawrenceville, Monmouth, Monticello, Mount Carmel, Mount Sterling, Muncie, Oakwood, Ogden, Oquawka, Pere Marquette State Park, Pike, Port Byron, Rock Island, Starved Rock State Park, Thomson, Urbana, Vienna, and Zion.

2. *Nesosteles neglecta* var. *pallidens*
DeLong

Eugnathodus neglecta var. *pallida* DeLong & Davidson (1933, p. 56). Name preoccupied. *Nesosteles neglectus* var. *pallidens* DeLong (1944b, p. 272). New name.

Length 3.0–3.5 mm. In form and general appearance similar to typical *neglecta*, but pale green or white in color. Disc of pronotum sometimes slightly darker than adjacent areas, and dorsal portion of abdomen black or dark brown. Genital characters as in typical *neglecta*.

This form was previously recorded from the southern states.

Illinois Records.—HEROD: Aug. 4, 1934, DeLong & Mohr, 1♂. MONMOUTH: at light, July 2, 1934, DeLong & Ross, 1♂.

Subfamily CICADELLINAE

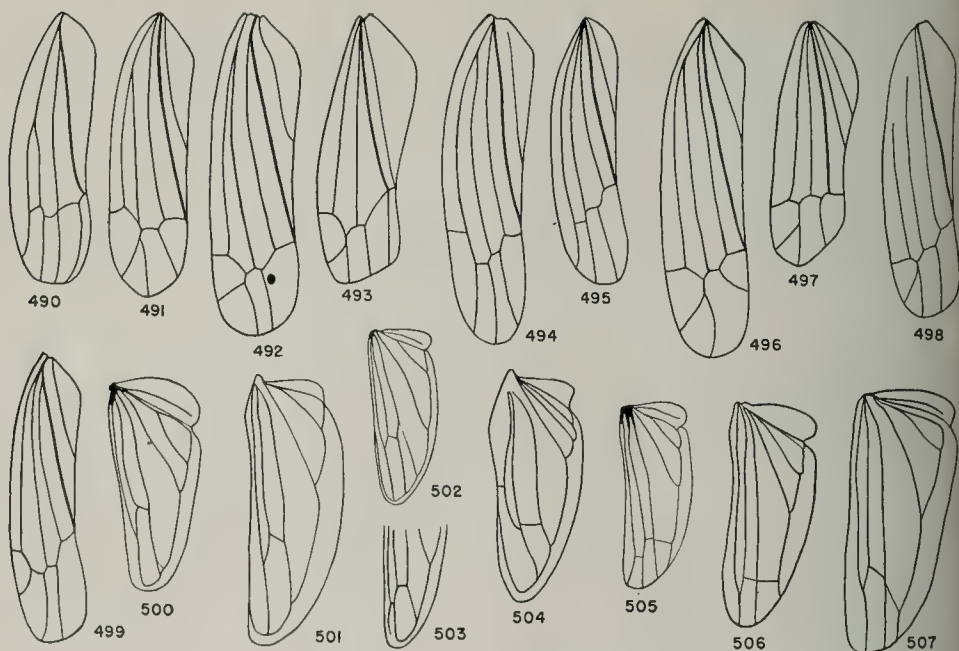
The insects of this group are small and frail. This characteristic alone will usually

separate them from those of other groups. The absence of crossveins anterior to the apical crossveins is always a good way to characterize these species, and the ocelli are often absent.

As mentioned in the foreword, the size of the group precluded a detailed treatment of the subfamily Cicadellinae in the present project. I have included, however, a key to the Nearctic genera of the subfamily, together with notes on generic diagnosis as an aid to the student in identifying material. As a further aid in this direction, citations are given under several genera to comprehensive taxonomic papers treating them.

KEY TO GENERA

1. Each elytron with definite appendix, with three or four closed apical cells, as in fig. 490.....2
2. Appendix curved and ending at about apical cell; elytra each with four apical and no anteapical cells, fig. 490. Each hind wing with curved anterior veins definitely surrounded by wing membrane.....110. *Alebra*
Appendix nearly straight, not extending to apical cell; elytra each with three or four apical cells, anteapicals sometimes present, fig. 493. Each hind wing with the curved anterior apical vein marginal.....109. *Protalebra*
3. Veins of hind wings ending in a marginal vein, apical cells closed, fig. 500.....4
Veins of hind wings extending to margin, one or more apical cells not closed, fig. 505.....10
4. Anterior apical vein of each hind wing not coalescing with costal margin, continuous with first sector in bounding the outermost closed apical cell, fig. 500...115. *Empoasca*



Elytra of Cicadellinae

- Fig. 490.—*Alebra albostriella*.
Fig. 491.—*Empoasca obtusa*.
Fig. 492.—*Alconeura rotundata*.
Fig. 493.—*Protalebra brasiliensis*.
Fig. 494.—*Dikraneura mali*.

- Fig. 495.—*Forcipata loca*.
Fig. 496.—*Typhlocyba* sp.
Fig. 497.—*Dikraneuroidea beameri*.
Fig. 498.—*Idona minuenda*.
Fig. 499.—*Erythroneura obliqua*.

Hind wings of Cicadellinae

- Fig. 500.—*Empoasca obtusa*.
Fig. 501.—*Idona minuenda*.
Fig. 502.—*Forcipata loca*.
Fig. 503.—*Joruma* sp.

- Fig. 504.—*Dikraneuroidea beameri*.
Fig. 505.—*Cicadella flavoscuta*.
Fig. 506.—*Typhlocyba querci*.
Fig. 507.—*Erythroneura obliqua*.

Anterior apical vein of each hind wing directed toward, often joining, costal margin, not continuous with first sector and not forming part of boundary of outermost distally closed apical cell, fig. 502.....5

5. Each hind wing with two closed apical cells, fig. 502.....6

Each hind wing with one closed apical cell, fig. 501.....8

6. Second apical cell of each elytron distinctly pedunculate at base, fig. 492.....113. *Alconeura*

Second apical cell of each elytron not pedunculate at base, fig. 494.....7

7. Elytra each with first crossvein present, fig. 494; male plates, fig. 512*A*, flat, triangular; female seventh sternite, fig. 512*C*, rounded.....112. *Dikraneura*

Elytra each with first crossvein wanting; second, third, and fourth crossveins spaced more distant from each other than above, fig. 495; male plates, figs. 514*A*, 514*B*, cylindrical, narrow, greatly separated at middle; female seventh sternite, fig. 514*C*, with a large median strongly produced lobe.....114. *Forcipata*

8. Elytral crossveins usually not meeting; third apical cell pedunculate, fig. 498.....116. *Idona*

Elytral crossveins usually in line; second apical cell pedunculate, fig. 497; hind wing as in fig. 504.....111. *Dikraneuroidea*

9. Hind wings with at least one closed and one open apical cell, fig. 503.....117. *Joruma*

Hind wings with no closed apical cells, fig. 505.....10

10. Hind wing with four veins extending to margin of wing, forming three open apical cells, fig. 505.....118. *Cicadella*

Hind wing with three veins extending to margin of wing, forming two open apical cells, fig. 506.....11

11. Elytra with fourth apical vein of each curving to rounded margin; second apical cell triangular, usually stalked, fig. 496.....119. *Typhlocyba*

Elytra with fourth apical vein of each more nearly paralleling margin, second apical cell quadrate, not stalked, fig. 499.....12

12. Scutellum elevated at apex, fig. 513*E*.....120. *Hymetta*

Scutellum flat, not elevated at apex.....121. *Erythroneura*

109. *PROTALEBRA* Baker

Protalebra Baker (1899, p. 402).

Fig. 493. This genus is characterized by having a definite appendix on each elytron, appendix not extending around the apex; the elytron has four apical and no ante-apical cells. The species of this genus are tropical or subtropical, and only two are recorded for the United States. One of

these, *brasiliensis* Baker (1899, p. 405), occurs in the United States in Florida and Texas only.

110. *ALEBRA* Fieber

Alebra Fieber (1872, p. 14).

Fig. 490. This genus has a definite appendix extending around the apex of each elytron. There are four apical and no ante-apical cells in the elytron. The vertex is usually rather broadly rounded and scarcely or only slightly produced anteriorly.

Insofar as known the members of this genus feed upon trees and shrubs. About a dozen species and varieties have been recorded for the Nearctic region. The common species of the genus in Illinois is *albostriella* (Fallen) (1826, p. 54).

111. *DIKRANEUROIDEA* Lawson

Dikraneuroidea Lawson (1929, p. 307).

Figs. 497, 504. The only member of this genus resembles certain species of *Dikraneura*, but it has only one closed apical cell in the hind wing. It is further distinguished from closely related genera by having the crossveins almost in a straight line. The only known species of this genus, *beameri* Lawson (1929, p. 307), occurs in Texas.

112. *DIKRANEURA* Hardy

Dikraneura Hardy (1850, p. 423).

Fig. 494. The genus *Dikraneura* belongs to the group of genera that have two closed apical cells in the hind wing. Each elytron has the first crossvein present, and one or both of the first and fourth crossveins are but little basad of the second and third; the latter two are usually but little basad of each other. The vertex is usually well produced and bluntly, sometimes pointedly, angled.

About 60 Nearctic species have been described, and several occur in Illinois. A common grassland and pasture species is *mali* (Provancher) (1890, p. 298). The vertex, female seventh sternite, and male genitalia are shown in fig. 512.

113. *ALCONEURA* Ball & DeLong

Alconeura Ball & DeLong (1925, p. 334).

Fig. 492. This genus is closely related to *Dikraneura* and contains species that are

small, robust, and usually highly ornamented. Each hind wing has two closed apical cells. Each elytron has four distinct apical cells; the second cell is always triangular and pedunculate. Due to the union of the second and third nervures for some distance at the base, the first cell is distinct but irregular in shape.

Griffith (1936) records 20 Nearctic species of *Alconeura*, and nearly all are found in the West and Southwest. One species, *rotundata* Ball & DeLong (1925, p. 335), has been taken in the states just west of Illinois, and may be collected at some time in this state.

114. *FORCIPATA* DeLong & Caldwell

Forcipata DeLong & Caldwell (1942, p. 49; see also 1936, p. 70).

Figs. 495, 502. The species of this genus have bluntly angled heads and resemble species of *Dikraneura* in form and general appearance. They are usually yellow, tinged with orange, and have genital structures that differ from those of allied genera. The male plates are cylindrical, strongly curved outwardly at base so that they are widely separated at middle. The female seventh sternite bears a large strongly produced median lobe that differs in shape among the species, but always occupies the median half or more of the posterior margin. Each elytron lacks the first crossvein, and the second, third, and fourth crossveins are more widely separated than in the *Dikraneura* elytron.

Ten species of *Forcipata* are known for the United States, of which *loca* DeLong & Caldwell (1936, p. 71; 1942, p. 49) is the most widely distributed eastern one. It is common in Illinois on small grasses in pastures and open woodland.

115. *EMPOASCA* Walsh

Empoasca Walsh (1862, p. 149).

Figs. 491, 500, 508. For the most part this genus contains small delicate greenish species of leafhoppers. The members of this genus can most easily be distinguished from their close generic relatives by the absence of an appendix on the elytron and by the presence of one apical cell in the hind wing, which is closed by a submarginal vein. As in other related genera there are

no anteapical cells present in either pair of wings.

Empoasca contains nearly 200 described Nearctic species, and several of them are of economic importance. Two common species in Illinois are *maligna* (Walsh) (1864,

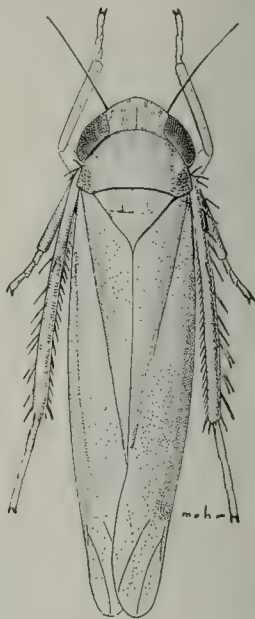


Fig. 508.—*Empoasca fabae*.

p. 317), fig. 510, occurring commonly on apple, and *fabae* (Harris) (1841, p. 186), fig. 511, which occurs on nearly all leguminous plants. The second species is especially a pest of clover, alfalfa, beans, and potatoes, and is frequently abundant on apple. Most of the species of this genus are so closely related that they can be distinguished only by characters of the male genitalia.

116. *IDONA* DeLong

Idona DeLong (1931, p. 50).

Figs. 498, 501. The genus may be characterized as having a strongly produced and bluntly pointed vertex. Each hind wing has only one closed apical cell. The crossveins of each elytron are not arranged in a straight line, and the third apical cell is parallel sided. One United States species with two varieties is known. The typical species, *minuenda* (Ball) (1921, p. 23), is greenish in color and resembles some species of *Empoasca*.

117. *JORUMA* McAtee

Joruma McAtee (1924, p. 34).

Fig. 503. This genus is characterized by having the hind pair of wings each with one closed and one open apical cell. In contrast to most of the genera of Cicadellinae, this genus has well-developed ocelli. The crossvein that should form the base for the first apical cell is rudimentary.

Two species are known for the United States; at least one of these, *pisca* McAtee (1924, p. 34), may be found in southern Illinois.

118. *CICADELLA* Duméril

Cicadella Duméril (1806, pp. 266-7, 334).

Eupteryx Curtis (1833, p. 192).

Fig. 505. In general appearance the members of the genus *Cicadella* resemble species of *Typhlocyba*, to which they are closely related. Each hind wing of *Cicadella* has no wing margin; so the four veins extending to the margin, forming three apical cells. In *Typhlocyba* only two apical cells are formed.

About 10 species of *Cicadella* are known for the United States. *C. flavoscuta* (Gillelette) (1898b, p. 749) has been taken in small numbers in Illinois. It lives upon ferns in wooded areas. Several other species probably occur here.

119. *TYPHLOCYBA* Germar

Typhlocyba Germar (1833, p. 180).

Figs. 496, 506. The species of the genus *Typhlocyba* are for the most part white, cream, or pale in color but often with bright markings. Most of the species feed upon trees and shrubs. These species have a blunt produced vertex, which is scarcely angled, almost rounded, and each hind wing has two open apical cells. The second apical cell of each elytron is triangular, usually with a basal stalk.

About 80 Nearctic species and varieties of this genus are known. Probably the most common and important species in Illinois is the white apple leafhopper, *pomaria* McAtee (1926, p. 29). It is a common pest of apple in the East and Middle West, and at times becomes very abundant, causing a considerable loss of chlorophyll in the leaves.

120. *HYMETTA* McAtee

Hymetta McAtee (1919, p. 121).

Fig. 513E. The chief character that separates this genus from *Erythroneura*, to which it is closely allied, is the thickened scutellum and the elevation of its posterior margin. The venational characters of the wing are very close to those of *Erythroneura*.

Eight species and varieties of *Hymetta* have been described for the United States. A common species on shrubbery in wooded areas is *trifasciata* (Say) (1825, p. 344).

121. *ERYTHRONEURA* Fitch

Erythroneura Fitch (1851, p. 62).

Figs. 499, 507, 509. This genus contains several hundred minute species of leafhoppers, many of which are pale, with color spots or stripes, or more generally brightly colored, especially with some shade of red. The vertex is produced, bluntly angled, with the apex often rounded. These leafhoppers belong to the group that has no closed apical cells in the hind wing and has two open or incomplete cells formed by three veins extending to the apical margin. *Erythroneura* differs from *Typhlocyba* and *Hymetta* by having the second apical cell quadrate instead of triangular.

Former workers, particularly McAtee (1920), Robinson (1926), and Beamer (1936b, 1946), have divided the species into various groups upon the basis of wing venation, and the following key to groups is based upon their work and adapted from it.

KEY TO GROUPS

1. Second sector of each elytron joining with the fourth apical vein at crossveins, forming a definite continuous line. 2
- Second sector of each elytron staggered at crossveins, not joining with the fourth apical vein. 3
2. Basal crossvein of fourth apical cell oblique. *maculata* group
- Basal crossvein of fourth apical cell square. *comes* group
3. Basal crossvein of fourth apical cell curved or sloping; vertex and pronotum marked with two stripes that diverge posteriorly. *obliqua* group
- Basal crossvein composed of two short veins that are angled with each other; vertex and pronotum usually without divergent stripes. *vulnerata-kansana* group

The *obliqua* Group

The species that are allied in this group have a color pattern consisting of oblique reddish lines or a V-shaped mark upon the vertex and pronotum; this pattern may be variously modified in both color and intensity so that a broad dark or reddish stripe may occur on each elytron, forming a rather solid stripe on the middle of the closed elytra. The pygofer hooks of this group are rather short, thick, pointed at the apical ends, each bearing a short process beneath.

The typical coloration of *obliqua* (Say) (1825, p. 342) is yellow, with two red stripes on vertex and pronotum, stripes diverging from apex of vertex. Elytra each with two oblique red stripes, one on each clavus and another on corium close to claval suture. There is also a reddish stripe along costal margin. In one common species, *lawsoniana* Baker (1926, p. 347), the color pattern is such that a broad stripe widens from apex of elytra. This stripe may vary in color from bright red to black. Both of the species mentioned above are commonly found on apple.

The *vulnerata* Group

The species of this group are all dark colored, with a pale median longitudinal line across vertex, pronotum, and scutellum. The crossveins, and frequently short portions of other veins, are white.

The most common species, *vulnerata* Fitch (1851, pp. 62, 63), is dark greenish, reddish, or brown, with median white line across vertex, pronotum, and scutellum, and a line bordering each eye. The pronotum is marked with white spots. Each of the elytra is marked with white on the clavus and corium. This species is common on grape and other vines.

The *kansana* Group

This group differs from the *vulnerata* group in color only and can scarcely be considered as a separate group. These species are not dark in color nor do they have the median pale stripe on the vertex, pronotum, and scutellum, but they are variable in color and seem to have no constant character to separate them from that group.

A common species of this group, *kansana* Baker (1925, p. 537), is characterized by

having a dark brown or black scutellum. The vertex varies in color from reddish with pale spots to dusky yellow. The pronotum may vary from yellow with reddish markings anteriorly and brown posteriorly

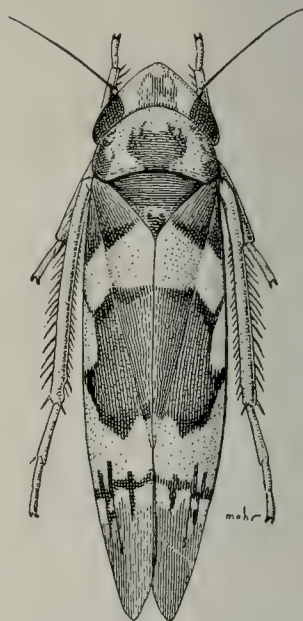


Fig. 509.—*Erythroneura vitis*.

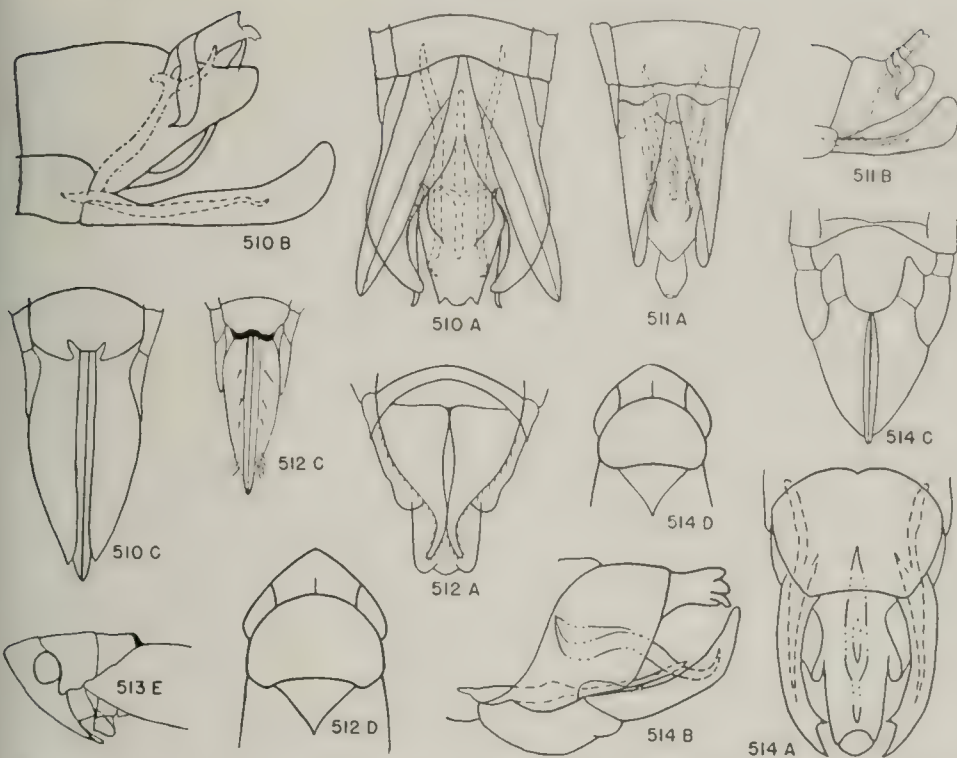
to a dark brown throughout. The elytra are pale, with reddish markings on each clavus, corium, and on crossveins. This species is often common on apple or ornamental plants.

The *maculata* Group

The species of this group can be separated from those of other groups by a wing character as noted in the key, and in addition the fourth apical cell is always marked by a black spot in basal portion. The pygofer hooks are long and spearlike.

Two color patterns are predominant in this group. The *maculata* type pattern, found in *maculata* (Gillette) (1898b, p. 764), is composed of a yellow or pale background upon which is a rather large number of small red or yellow spots. The other color pattern is either a transverse or oblique band of red or some shade of brown upon a pale background. *E. basilaris* (Say) (1825, p. 344) is a common example of this second group.

E. maculata is a common species on wild

Fig. 510.—*Empoasca maligna*.Fig. 511.—*Empoasca fabae*.Fig. 512.—*Dikraneura mali*.Fig. 513.—*Hymettia trifasciata*.Fig. 514.—*Forcipata loca*.

Cicadellinae: *A*, ventral aspect of male genitalia; *B*, lateral aspect of male genitalia; *C*, female genitalia; *D*, head and pronotum; *E*, head, thorax, and scutellum, lateral aspect.

and cultivated grape, and at times becomes abundant on *Crataegus*. *E. basilaris* is one of the common species on apple and ornamental plants.

The comes Group

This group is one of the largest of the genus, and the species are rather difficult to separate. As noted, this group has the fourth apical cell with a square base; the second apical cell has either a black spot or a smoky area in its apical portion, and the base of the fourth apical is similarly marked. Pygofer hooks of the male genitalia form U-shaped processes that bear caudally directed processes, the ventral one of which is always longer.

In color the members of the *comes* group vary greatly, and there is no uniform color pattern that can be used in recognizing the

species of this group. Certain species are very pale, either with no markings, as in the case of *delicata* McAtee (1920, p. 317), or with faint markings, which are not easily recognized. Other species, for example *infusata* Gillette (1898b, p. 764), are almost entirely dark brown. Still others are marked with bands or stripes. *E. trilineata* (Fitch) (1851, p. 63) has transverse bands, and *ziczac* Walsh (1862, p. 149) is marked with some rather broad zigzag longitudinal stripes.

E. comes (Say) (1825, p. 343), is common on wild and cultivated grape; *ziczac* is common on certain ornamental vines, especially Boston ivy. It also occurs on wild grape, poison ivy, and Virginia creeper. *E. trilineata* is one of the well known and more distinctly marked grape leafhoppers, and it is also found on several of the ornamental vines.

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BULLETIN

of the

ILLINOIS NATURAL HISTORY SURVEY

HARLOW B. MILLS, *Chief*

The Bass-Bluegill Combination in a Small Artificial Lake

GEORGE W. BENNETT



Printed by Authority of the
STATE OF ILLINOIS
DWIGHT H. GREEN, *Governor*

DEPARTMENT OF REGISTRATION AND EDUCATION
FRANK G. THOMPSON, *Director*

STATE OF ILLINOIS

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NATURAL HISTORY SURVEY DIVISION

HARLOW B. MILLS, *Chief*

Volume 24

BULLETIN

Article 3

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GEORGE W. BENNETT



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URBANA, ILLINOIS

December 1948

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This paper is a contribution from the Section of Aquatic Biology.

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The frontispiece shows wing nets being set in Fork Lake, 1939. In the first year of cropping, only two or three wing nets were required and these were set with individual leads that had no relation to one another. In other years, six wing nets were required and were arranged in such a way as to trap fish in all but the deepest part of the pond.



The Bass-Bluegill Combination in a Small Artificial Lake

GEORGE W. BENNETT

TEN years ago, Fork Lake, a pond of 1.38 acres on the farm of Paul S. Smith near Mount Zion, Illinois, was probably typical of many of the older man-made ponds in central Illinois. When this pond was assigned for study to aquatic biologists of the Illinois Natural History Survey in 1938, it was 18 years old and had been used extensively for fishing, waterfowl shooting, and general outdoor recreation. A brief history of the recreational benefits derived from the pond has been published elsewhere (Thompson & Bennett 1939a).

With the outlawing of duck baiting and use of live decoys in 1935, the success of waterfowl shooting on Fork Lake was limited. Fishing, which was considered good from 1926 to 1930, had become poor through the development of large populations of black bullheads, carp, and buffaloes. These undesirable fishes apparently were limiting the success of reproduction and curtailing the growth rates of largemouth bass, crappies, bluegills, and other sunfish in the pond.

Fish in the pond were poisoned with rotenone on June 7, 1938, and a census was made of them (Thompson & Bennett 1939a). At this time, Fork Lake contained 5,350 fish weighing 774 pounds and consisting of 16 species. The rough fish, mostly carp and redmouth buffalo, made up 47.5 per cent by weight of all fish, and bullhead (plus four channel catfish) 41.2 per cent. Largemouth bass and panfish totaled only 6.3 per cent of the weight of all fish. The weight of fish per acre was 539 pounds, which indicated a moderately high natural fertility for the pond. At the time of the census, Fork Lake contained only 145 fish of desirable species and of a size large enough to interest anglers.

The pond was restocked between June 11 and 18 with 270 stunted adult bluegills,

Lepomis macrochirus Rafinesque, weighing about 40 pounds and 1,440 largemouth bass fry, *Micropterus salmoides* Lacépède, weighing 0.15 pound. Both the bluegills and the bass were taken from Homewood Lake, near Decatur, Illinois. The bluegills began to spawn almost at once; on June 22, 27 bluegill nests were counted. The bass averaged 0.87 inch total length when stocked, and, during October, 74 taken on fly-rod lures averaged 6.45 inches. Some of the young bluegills that were spawned in 1938 and escaped being eaten by bass were nearly 3.75 inches long by October; others were less than 0.75 inch.

Early in 1939 the decision was made to crop the new fish population by using 1-inch-mesh wing nets, 1-inch-mesh (bar) seines, and hook and line, and to determine the effect of such cropping upon this bass-bluegill population.

Cropping efforts resulted in a substantial yield of fish in 1939 (Bennett, Thompson, & Parr 1940). The annual yields of bluegills were smaller in 1940 and 1941. The yields of bass, although numerically smaller in 1940 and 1941 than in 1939, increased in total weight each year from 1939 to 1941, inclusive.

In the case of the bluegills, the first brood spawned in the lake grew more rapidly than all the others. Each successive brood of bluegills grew less rapidly than the preceding brood in spite of intensive cropping, which might have been expected to reduce the competition for food and result in improved rates of growth. Successive yearly yields in pounds of bluegills also progressively decreased. I believe that counter forces that reduced the food available for bluegills were responsible for the decline in yield and the absence of growth compensation.

Two possible causes for a reduction in bluegill foods, which may be assumed to

have been responsible for a reduced yield of bluegills, were (1) loss of fertility of the pond resulting from the removal of a large poundage of fish and (2) the spread of rooted aquatic plants to reduce greatly the area of open water.

The Fork Lake experiment was terminated by run-off water from a 4-inch rain that washed out the dam on July 8, 1942. As no Natural History Survey personnel were present at the time the actual break occurred, fish collected were those that remained in the pond after about two-thirds of the water had flowed out through the break, carrying with it a part of the fish population. In spite of this unfortunate circumstance, which eliminated the possibility of a final complete census of the fish, the partial census and the collections of previous years gave interesting and significant information on the bass-bluegill combination.

Acknowledgments

Many persons assisted in the Fork Lake investigation. Dr. David H. Thompson initiated the study in 1938 and cooperated with the author on the field investigations in 1939 and on the preparation of the two preliminary Fork Lake reports. Mr. Sam A. Parr, formerly an Inspector with the Illinois Department of Conservation and now Superintendent of Fisheries with that Department, gave invaluable assistance in field observations and cropping. Assistance in collecting monthly quotas of fishes was given by many members of the Natural

History Survey staff, among whom were Dr. Donald F. Hansen, Dr. Louis A. Krumholz, Dr. Lee E. Yeager, Mr. Bruno von Limbach, Mr. Francis X. Lueth, Dr. C. L. Schloemer, and Dr. Gernon P. Hesselschwerdt. I am indebted to Mrs. Mary Shanor and Dr. Marian F. James, employed by the Natural History Survey for making stomach analyses of bass and bluegills. Dr. Herbert H. Ross, Systematic Entomologist of the Survey, and his staff gave valuable assistance to Mrs. Shanor and Dr. James in the identification of aquatic insects.

To Mr. Paul S. Smith, owner of Fork Lake, I am grateful for the use of the pond and for the many pertinent observations that he made during the early years of the experiment.

Cropping Procedure

It was not feasible to take a large annual crop of fish by hook and line from Fork Lake; the Natural History Survey staff was unequal to the task and local people who cared to fish and who would keep records were few. Moreover, since many fish were needed for laboratory study, and a uniform sequence of collections was desirable, it was decided to crop the pond with nets and to augment the net catches with hook-and-line fishing. Nearly all anglers condemn the man who uses a trap net or seine as a game-fish poacher (whether the use of nets for commercial fishing is legal or not). Because such gear is frequently considered responsible for the

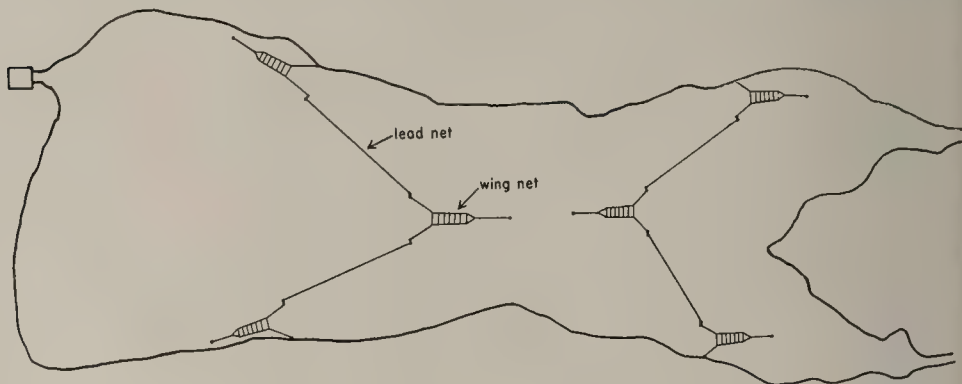


Fig. 1.—Outline map of Fork Lake, showing the customary set position of wing nets and lead nets used in cropping the pond during 1940, 1941, and 1942. It was not always possible to block off the pond completely as is shown, for the bottom near shore was often hard and frequently would not support the outer wing pole of a net. With the arrangements of nets shown here, no fish could swim for any great distance without running into a lead or net.



Fig. 2.—Six wing nets were needed to crop the fish in Fork Lake in 1940, 1941, and 1942. These nets were set in groups of three, with leads blocking the pond between them, as shown in fig. 1.

depletion of our game fishes, it seemed of considerable value to use this type of equipment in cropping the pond.

For a number of years, members of the aquatic biology staff of the Natural History Survey have used a wing net or fyke net for sampling fish populations in Illinois lakes and streams. This net, similar to the wing nets used by commercial fishermen on the Illinois River, consists of a tapered cylinder of webbing supported by hoops, open at the large end and closed at the small end by a drawstring. Inside are two funnels composed of webbing, the first located just inside the open end of the net and the second about two-thirds of the distance from front to back. Attached to the hoop at the large open end of the net are two pieces of webbing, the wings, that are spread when the net is set and that function in leading fish into the net much as the wing fences on a cattle chute lead in the cattle, fig. 1. A separate lead

net (much like a gill net or seine) is often used with a wing net to form an underwater "drift fence"; occasionally wing nets are set at both ends of such a lead net. Fish are believed to swim up to this lead, and follow it along until they find themselves within the mouth of the wing net. Wing nets are not ordinarily baited except for catfish; fish wander into the nets and are unable to find a way out. In shallow water these nets and leads are supported by long poles forced into the bottom mud. The webbing of legal commercial nets in Illinois must measure a minimum of 1.5 inches between knots on each of the four corners of a square mesh. Wing nets used at Fork Lake were of somewhat smaller mesh (0.50 to 0.75 inch) and would hold bass as small as 5 inches in length and bluegills of 3.5 inches.

Most of the cropping of Fork Lake was accomplished in 1939 by using two or three wing nets of 3.5 feet and 4.5 feet

in hoop diameter. In 1940 and later years, it became necessary to use six wing nets, four having front hoops of 3.5 feet in diameter and two having front hoops of 4.5 feet, fig. 2. In 1939, each wing net was supplied with a separate lead net; in 1940, 1941, and 1942, the six nets were set in two groups of three nets each with lead nets blocking the pond between them, as shown in fig. 1. With this arrangement, no fish could swim for any great distance without running into a lead or wing net.

Usually at 24-hour to 48-hour intervals after being set, nets were raised and the fish removed. Nets were moved frequently if they failed to catch fish. An attempt was made to fish the wing nets for a period each month from March to November of each year, beginning in March, 1939, and ending with the washout in July, 1942. Most of the fish caught were taken to the Urbana laboratories alive or iced, where they were weighed, measured, scaled, and dissected for stomachs and gonads. A small number of fish from Fork Lake were used to stock several new ponds constructed on farms near Mount Zion.

Some collections in early spring and late fall were made by seine hauls with a 100-yard, 1-inch-mesh seine. These hauls were necessary because the fish did not move enough to be caught in sufficient numbers in wing nets. Although some fish were taken with the seine, a satisfactory haul was difficult because of brush and snags in the bottom of the pond.

Table 1 lists the net-days of fishing in Fork Lake for the years 1939, 1940, 1941, and 1942.

The length of time that nets were fished each month usually depended upon the catch. If good catches (15 to 25 pounds of fish) were made, the nets were removed after two raises. If catches were poor, the nets were left in the lake as long as practicable. Table 1 indicates that more net-days of fishing were required with each succeeding year, and table 5 shows that in spite of an increase in net-days of fishing the total yield in pounds went down each year. This decrease in the fish yield produced by nets may have been influenced by one or both of two possibilities: (1) a reduction in the fish production of the pond and (2) a gradual improvement in the ability of the fish to avoid the nets or find a way out of them. Bass were much

more successful in avoiding nets than were bluegills. Even in 1939 so few bass entered the nets that angling was necessary to produce adequate samples. As the original bass fry grew larger, 1939-1942, they became more and more difficult to catch in nets. Bass of later broods, also, were caught more readily when small (5 to 7 inches) than when larger.

Bluegills were taken in nets most readily in the spring throughout April and May and more readily in fall than in summer. They were sometimes induced to move by violent storms or the flowing of warm water into the pond from the watershed. For example, nets set on March 9, 1942, caught few fish until a warm rain during the night of March 16 drained from the surrounding lands into the pond. When the nets were raised on March 17, they contained so many bluegills that some were replaced in the pond.

The amount of hook-and-line fishing done in Fork Lake to augment the catch of bass by nets was moderate. Nearly always done from a boat, fishing was with fly rod or bait rod and usually with artificial baits. Angling periods were usually short (one-half to 3 hours) and represented such time as was available on days when net raising or observations necessitated a trip to the pond. Hook-and-line catches varied from 16 fish per man-hour on May 6, 1941, to zero catches on several occasions. Table 2 gives the hook-and-line catch summary for years of the study and shows man-hours of fishing catch per man-hour, and numbers of bass and bluegills taken.

It is difficult to explain why no fish were caught on hook and line in 1942. Part of the failure to catch fish was due to a late, cold spring accompanied by excessive rainfall, which increased the turbidity of the pond and kept the water abnormally cold. The larger bass present (between 12 and 15 inches long and 1.0 and 1.5 pounds in weight) had become increasingly difficult to catch in 1941, and apparently had learned through observation (because bass were seldom returned to the water when caught) to ignore artificial lures. In 1942 the pooriness of fishing gave the picture of a pond "fished out" for bass. That the lake was not "fished out" was shown by the catch of bass in the washout described later. Actually, during the spring of 1942,

Table 1.—Net-days of fishing with 1-inch-mesh wing nets in Fork Lake, March, 1939, to June, 1942.

MONTH	NET-DAYS OF FISHING			
	1939	1940	1941	1942
March	S-6*	S-3*	48	48
April	14	36	30	36
May	8	36	60	36
June	6	20	36	48
July	8	18	36	—
August	8	24	24	—
September	15	—	54	—
October	15	48	42	—
November	18	S-2*	—	—
Total	92	182	330	168

*S designates that hauls were made with a 100-yard, 1-inch-mesh seine; the numeral following the S indicates the number of such hauls.

Table 2.—Hook-and-line catch of largemouth bass and bluegills from Fork Lake, 1939, 1940, 1941, 1942.*

YEAR	TOTAL MAN- HOURS OF FISHING	AVERAGE CATCH PER MAN- HOUR	NUMBER OF LARGE- MOUTH BASS	NUMBER OF BLUE- GILLS
1939	27.0	1.37	34	3
1940	36.3	3.20	116	1
1941	42.3	2.90	122	28
1942*	26.5	0.00	0	0

* March–June only in 1942. All other years March–October.

Fork Lake contained more than 75 bass of over 10 inches in length and many more of smaller sizes.

Fish were removed from Fork Lake when captured in wing nets, seines, or by angling, except in a few cases when the catch was less than 5 individuals, and in a single case (March 17, 1942) when more fish were caught than could be processed. By arrangement with the State Department of Conservation, state fish code restrictions were dispensed with; bass were taken during the closed season, and no length limits or creel limits were observed on either bass or bluegills.

On several occasions fish from Fork Lake were used for stocking other ponds. Adult fish used for this purpose were weighed and measured when caught. Bass and bluegill fry were measured and counted, and an estimate was made of their total weight.

Fish Yield

The total yield of bass for the years 1939–1941 and the early part of 1942 is shown in table 3. The 1938 brood (original fry stocked) made up 87 per cent of the yield (weight) for all years, and, in the years in which cropping continued through November, the total weight of bass taken remained fairly constant at around 50 pounds (51.0, 53.9, and 57.7). No bass were spawned in 1939 because the original stock was not sexually mature in that year. Neither the 1940 nor the 1941 broods of bass were well represented in the net or hook-and-line catches, presumably because these broods were preyed upon by the original brood.

The number of bluegills taken from Fork Lake is shown in table 4. The original stock was sexually mature and produced a brood of young in 1938. Each year the bluegills produced a new brood, which usually appeared in large numbers in the nets during the following season. In 1940 some bluegill fry of the year were seined for stocking a nearby pond and some were trapped in the nets by strands of *Spirogyra* and failed to fall through the meshes. While it was readily possible to separate the original stock and the 1938 brood fish from later broods, the range in size of the individuals of the 1939, 1940, and 1941 broods overlapped so that separation of most bluegills into their various broods was done on the basis of scale studies. The original stock made up 16.5 per cent by weight of the total catch during the study, the 1938 brood 55.8 per cent, the 1939 brood 19.9 per cent, and the 1940 brood 7.7 per cent.

Table 5 gives a summary of the total yield of largemouth bass and bluegills taken from Fork Lake by netting and angling during the study. The yield of bass (1939–1941) showed a slight rise from 51 to 58 pounds, but that of bluegills dropped from 172 pounds in 1939 to 72 pounds in 1941. As may be seen from tables 1 and 2, the intensity of fishing both with nets and angling devices was increased with each successive year. The yield for the first 4 months of 1942 suggests that, if the cropping could have been continued through November, the 1942 yield of bluegills might have been nearly equal to that of 1941.

Table 3.—Largemouth bass removed from Fork Lake, March–November, 1939, 1940, 1941; and March–June, 1942.

BROOD	1939		1940		1941		1942		TOTAL		PER CENT OF TOTAL WEIGHT
	Number	Weight, Pounds	Number	Weight, Pounds	Number	Weight, Pounds	Number	Weight, Pounds	Number	Weight, Pounds	
1938*	349	51.0	208	52.7	72	39.6	10	17.4	639	160.7	86.6
1940	—	—	105	1.2	23	7.3	3	1.8	131	10.3	5.5
1941	—	—	—	—	91	10.8	27	3.7	118	14.5	7.9
Total	349	51.0	313	53.9	186	57.7	40	22.9	888	185.5	100.0

*Original stock.

Table 4.—Bluegills removed from Fork Lake, March–November, 1939, 1940, 1941; and March–June, 1942.

BROOD	1939		1940		1941		1942		TOTAL		PER CENT OF TOTAL WEIGHT
	Number	Weight, Pounds	Number	Weight, Pounds	Number	Weight, Pounds	Number	Weight, Pounds	Number	Weight, Pounds	
Original stock	162	57.0	27	12.2	2	1.4	—	—	191	70.6	16.5
1938	773	115.0	427	108.0	35	13.3	7	2.7	1,243	239.0	55.8
1939	5	0.4	312	25.8	336	51.8	35	7.3	687	85.3	19.9
1940	—	—	246	0.3	145	5.5	193	27.2	584	33.0	7.7
1941	—	—	—	—	19	0.2	18	0.4	37	0.6	0.1
Total	940	172.4	1,012	146.3	537	72.2	253	37.6	2,742	428.5	100.0

Table 5.—Yield of largemouth bass and bluegills from Fork Lake, March–November, 1939, 1940, 1941; and March–June, 1942.

SPECIES	1939		1940		1941		1942	
	Number	Weight, Pounds	Number	Weight, Pounds	Number	Weight, Pounds	Number	Weight, Pounds
Largemouth bass.....	349	51.0	313	53.9	186	57.7	40	22.9
Bluegills.....	940	172.4	1,012	146.3	537	72.2	253	37.6
Total.....	1,289	223.4	1,325	200.2	723	129.9	293	60.5
Per acre.....	934	161.9	960	145.1	524	94.1	212	43.8

Dam Failure

The Fork Lake cropping experiment was suddenly terminated by run-off from a 4-inch rain that occurred within a few hours, early in the morning of July 8, 1942, when the Fork Lake dam, fig. 3, constructed without expert engineering assistance and apparently riddled with muskrat burrows above the normal water

level, gave way near the middle, probably some time between 10:00 A.M. and noon. Dr. G. P. Hesselschwerdt and I were approaching Fork Lake at about 12:45 P.M. and, before we arrived within sight of the pond, we could hear the roar of water and realized the dam had washed out. At 12:45 about two-thirds of the total volume of water had poured out through the break. Much of the water must have flowed out

with the initial failure of the dam, as the corn stalks were flattened in the field below over a much wider area than the flow covered at the time of our arrival. Probably any fish that were in the pond area immediately adjacent to the break at the time it occurred were washed across the

with the outflowing water into the net. Bluegills seemed less able to adjust themselves to the situation and most of them were stranded in the pond basin.

When we attempted to collect the stranded fish by walking into the pond basin, fig. 4, each of us in turn became



Fig. 3.—Lower end of Fork Lake, showing the dam. Rippapping of broken concrete was held by fencing of wire mesh. This rippapping prevented washing from wave action but was attractive to burrowing muskrats.

cornfield and into the stream that winds through the valley below. Water continued to flow out of the basin until 2:20 P.M.

At the time of our arrival, we staked a short piece of 1-inch-mesh netting across the break in the dam to trap the larger fish still within the pond basin. Fifty-four bass and 10 large bluegills were taken in the net set across the break. All these fish made an active attempt to leave the lake with the water. Most of the bass held back until only about a foot of water remained in the basin; then many swam

mired in hip-deep silt a few feet from the former shore line. Because of the impossibility of collecting the fish, we made a careful count by walking around the shore line and listing the bass and bluegills as belonging to the various broods on the basis of size. As the pond was long and relatively narrow, we found it possible to walk along each side and count fish lying stranded in the strip of bottom from the shore line to the trickle of water running through the center of the basin. Probably some fish had become buried in the soft mud, and so escaped being counted.

The band of vegetation completely encircling the shore line and filling the upper one-fourth of the pond (see map, fig. 5) flattened down over the mud when the water flowed out of the lake and may have

As the last of the water was running out of the lake, several small muskrats left their burrows and ran around in the mud of the pond basin as if lost. Six adult bullfrogs crawled around in the mud. Many



Fig. 4.—The basin of Fork Lake at the time of the dam failure, July 8, 1942. The break in the dam occurred near the center, supposedly as a result of a heavy rain and muskrat tunneling above the normal water line. The bottom of the white exposed portion of the gage board (upper left) marks the former water level.

hidden a few additional large fish. This vegetation was covered by hundreds of small bass and bluegills that had wriggled to the surface of the vegetation mat with their dying exertions. We estimated that there were at least 10,000 bluegills between one-half and 2 inches long, and not less than 5,000 bass between 1 and 4 inches. After the count was completed, the bass and bluegills that were captured in the seine were taken to the laboratory and processed. Table 6 gives an estimate of the total number and weight of fish observed. The weight amounted to approximately 260 pounds.

Many bullfrog tadpoles, *Rana catesbeiana* Shaw, were also in the vegetation.

large clams, *Anodonta grandis* Say, were exposed and died after moving a few feet.

Experience in draining ponds for making fish censuses indicates that, when a body of water is rapidly drained, bass swim against the current and usually most of them remain in the pond until the water has been lowered to a certain level, when they appear to reverse their behavior and attempt to move through the outlet. Bluegills are weaker swimmers and consequently many are washed out with the water before the bass begin to appear in numbers at the outlet.

The break in the dam at Fork Lake was V-shaped. The initial flow of water was large and probably carried away many

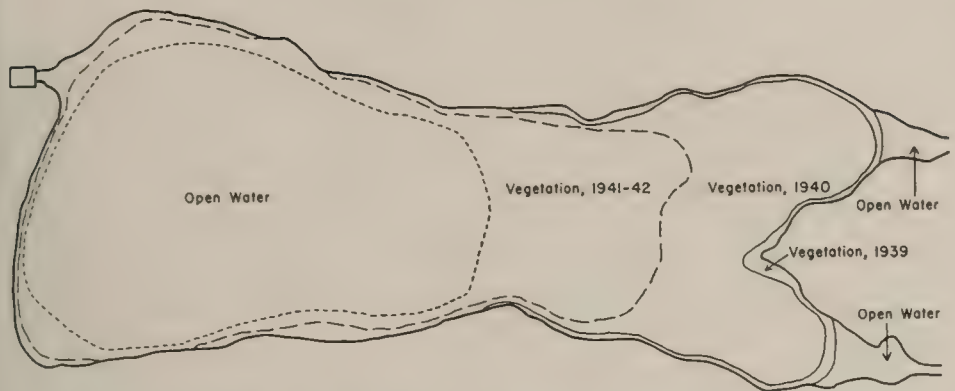


Fig. 5.—Outline map of Fork Lake, showing encroachment of the pondweed, *Potamogeton foliosus* Rafinesque, on the pond shallows. In 1939, plants of this species occupied a narrow band around the shore of the upper one-third of the pond; in 1940, it spread into water 3 to 4 feet in depth and encircled the pond shore line; in 1941 and 1942, it filled the shallows up to 5 or 6 feet in depth, leaving only a little more than one-half of the pond area in open water. Open water was always present in the upper forks of the pond because overhanging trees completely shaded these pockets.

more bluegills than bass. What the total weight of the population was can be only conjectured. The deep, open water in the region of the dam was of a type attractive to bluegills beyond the size range of bass food. Certainly the numbers of fish actually observed indicate that the pond contained a large fish population in spite of 3½ years of heavy cropping with nets, and the many small fish inhabiting the vegetation indicate a very successful spawn in 1942.

Pond Habitat

No attempt was made to study the plankton or the invertebrate or vertebrate fauna of Fork Lake other than the fish, except when an abnormal abundance of some species could not escape observation or when plants or animals other than fish appeared in the nets. The most obvious change in the pond habitat during the 4½ years it was under observation resulted from the spread of a

Table 6.—Fish observed at Fork Lake at the time of the dam failure of July 8, 1942.

BROOD	MEASURED AND WEIGHED INDIVIDUALLY			COUNTED BUT NOT WEIGHED		ESTIMATE OF TOTAL OBSERVED POPULATION	
	Number	Total Weight, Pounds	Average Weight, Pounds	Number	Estimated Weight, Pounds	Number	Weight, Pounds
Largemouth bass							
1938.....	34	59.7	1.76	32	56.3	66	116.0
1940.....	4	4.7	1.17	7	8.1	11	12.8
1941.....	16	12.6	0.79	16	12.5	32	25.1
1942.....	—	—	—	—	—	5,000	15.0
Total.....	54	77.0	—	55	76.9	5,109	168.9
Bluegills							
1938.....	10	5.7	0.57	20	11.3	30	17.0
1939 and 1940..	—	—	—	278	50.0	278	50.0
1941 and 1942..	—	—	—	—	—	10,000	25.0
Total.....	10	5.7	—	298	61.3	10,308	92.0

species of rooted aquatic vegetation, namely the fine-leaved pondweed, *Potamogeton foliosus* Rafinesque. Previous to the complete removal of fish in 1938, the pond contained no aquatic vegetation because the activities of bottom-rooting fish kept the water very turbid. The replacement of these fish by largemouth bass and bluegills allowed the silt to settle, and after June of 1938 the pond was turbid only following heavy rains. The source of silt was a clay fill for a road about 150 yards above the pond. Most of the rest of the drainage basin was in timber and grass. The reduced turbidity of the pond was not immediately followed by a growth of aquatic plants; a few bunches of fine-leaved pondweed appeared in the late summer of 1938.

By midsummer of 1939 a dense, narrow band of *Potamogeton foliosus* was growing in water from the shore out to a depth of 2 feet along the shore line of the upper one-third of the pond. In 1940, the fine-leaved plant spread into deeper water at the upper end of the pond and extended its distribution to form a band along the entire shore line of the pond—the edge of this band farthest from shore extended into water between 3 and 4 feet in depth. A vegetation map of the pond was made at the period of maximum plant growth in early August, fig. 5. When the open water of the pond was measured with a planimeter on this vegetation map, it was found to be slightly more than 0.95 acre, as compared with an open water area of 1.25 acres in 1939. The plants in this band of vegetation extended to the surface and were so thick that it was difficult to row a boat through them.

The following year (1941) the potamogeton extended its growth into still deeper water, fig. 5. The maximum depth at which the plants reached the surface was 6 feet, and most of the shore band of plants extended to depths a little beyond 5 feet. A measurement of the open water as outlined on a vegetation map made July 28 gave an area of 0.64 acre.

By the time the 1941 vegetation map was made, a circular area of approximately 10 feet in diameter, at a point near shore immediately between the forks of the upper end of the lake, had become completely denuded of plants. As a heavy growth of plants had been present in this location

earlier in the summer, the barren area was recorded. The water in the barren area was clear and it was possible to see bottom there. The water depth of this area ranged from 1 foot near shore to 3 feet at the outer edge of the opening.

The pond was not visited again until August 19, 23 days after the vegetation was mapped. On this date the *Potamogeton foliosus* was completely gone, except for a few scattered stalks at the water's edge, and the water was turbid with a "bloom" of algae, *Aphanizomenon flos-aquae* (Linnaeus), that obscured a Secchi disk lowered to 1.2 feet. Whether the small open area observed the latter part of July represented the beginning of a progressive die-off of the potamogeton is not known. A few small bunches of *Potamogeton nodosus* Poiret growing in shallow water along the south shore seemed to be unchanged. This phenomenon of a sudden die-off of *P. foliosus* in midsummer had been observed in one other experimental pond. In both instances, however, it was a "before and after" observation; neither pond was observed during the progress of the die-off.

The cause of this sudden die-off is unknown and it is believed to be of uncommon occurrence. Usually, dense mats of *Potamogeton foliosus* remain until late September, when they gradually break loose from their attachments and float free for some time before finally disintegrating. The phytoplankton "bloom" that followed the disappearance of the potamogeton is believed to have resulted from the release of plant nutrients into the pond water.

In 1942, in spite of a late, wet season, the fine-leaved pondweed again appeared in abundance and by the latter part of June had grown to fill the same parts of the pond that had been filled the preceding year.

It is probable that the application of the rotenone in June of 1938 killed not only the fishes but also the Entomostraca and, where excessive concentrations occurred, a part of the insect larvae of the littoral zone and the benthos (Smith 1940; Brown & Ball 1943). The rapid growth of bass fry and bluegills during the summer indicates that replenishment of small aquatic invertebrates must have taken place within a very short time. The result of a sudden catastrophe, such as rotenone treatment of a pond, is often a simplification of the in-

vertebrate fauna, some species disappearing entirely and other forms disappearing temporarily but reappearing later in eruptive numbers. This reaction is assumed to have taken place in 1938 in Fork Lake, particularly among the smaller invertebrates.

Fork Lake contained a number of adult bullfrogs, *Rana catesbeiana*, and their tadpoles were extremely numerous throughout the summer of 1938. The only other year in which tadpoles were present in large numbers was 1941, although a few could be seen at almost any time among the aquatic vegetation.

Crayfish, *Cambarus virilis* Hagen and *C. propinquus* Girard, must have been fairly abundant throughout the period of cropping of the pond, as large adults were taken often in wing nets. Both snapping, *Chelydra serpentina* (Linnaeus), and painted turtles, *Chrysemys picta marginata* (Agassiz), found a way into nets and frequently were drowned before the nets were raised. In some raises the poundage of turtles greatly exceeded that of fish. Snapping turtles removed from the pond in 1939 were 9 weighing 28.7 pounds; in 1940, 11 weighing 23.2 pounds; in 1941, 5 weighing 14.5 pounds; and in 1942, 3 weighing 7.1 pounds. The painted turtles removed in 1939 were 32 weighing 20.3 pounds; in 1940, 8 weighing 7.6 pounds; in 1941, 6 weighing 6.8 pounds; and in 1942, 4 weighing 5.3 pounds. Turtles found dead in the nets were removed from the pond. Some of the live turtles caught in nets were removed for laboratory study or for table use. Others caught were released.

Vegetation vs. Fish Yield

At the same time that the annual poundage of fish from Fork Lake went steadily

downward from 1939 through 1941, in spite of an increased intensity of fishing with nets and an increase in man-hours of angling, the mat-forming aquatic vegetation continued to spread. While other factors undoubtedly reduced the yield of fish from the pond, I believe that the increased abundance of plants was the most important factor.

A comparison of the yields of fish with the areas of open water is shown in table 7. The yields of fish are, of course, not exactly proportional to the areas of open water in the pond. But even though netting and angling pressures were increased during the 3 years, and many other factors probably influenced the fish yield, a remarkably close parallel existed between the fish yields and the open pond acreages, table 7. Swingle (1945) investigated a pond that became filled with a heavy growth of naiad, *Najas guadalupensis* (Sprengel), during years when this plant was not shaded out by muddy water. He concluded that the rank plant growths did not reduce the production of fish but did materially reduce the hook-and-line yield. Although information on the total weight of the fish population of Fork Lake, before and after the plants became abundant, is not available, the evidence presented in table 7 and the fact that the growth rate of bluegills became slower in spite of heavy cropping (see section following) suggest that the production of food available to fish in the pond was actually reduced by *Potamogeton foliosus*.

Growth Rates

The growing season for Fork Lake fish (water temperature above 55 degrees F.) was determined to be about 6 months long in 1939 (Bennett, Thompson, & Parr

Table 7.—Yield of fish, fishing effort, and approximate area of open water in Fork Lake, 1939, 1940, and 1941.

YEAR	YIELD		AREA OF OPEN WATER		NET-FISHING INTENSITY		ANGLING INTENSITY	
	Pounds	Per Cent of 1939 Yield	Acres	Per Cent of 1939 Area	Net-Days	Per Cent of 1939 Net-Fishing	Man-Hours	Per Cent of 1939 Angling
1939..	223.4	100.0	1.25	100.0	92	100.0	27.0	100.0
1940..	200.2	89.6	0.95	76.0	182	197.8	36.3	134.4
1941..	129.9	58.1	0.64	51.2	330	358.7	42.3	156.7

1940), and probably the growing season length varied from this time no more than a few weeks in other years.

These relatively small differences in the growing seasons had less influence upon fish growth than such factors as available food and related competition for food.

Frequent collections and examinations of fish from Fork Lake gave total length measurements that were useful in plotting

lected and preserved between late June and mid-September, 1938.

The 270 bluegills that were moved to Fork Lake from Homewood Lake between June 11 and 18 were very thin and were between 5 and 7 inches total length. On the basis of the first spring collection of the following year, these fish may be said to have grown rapidly in 1938; they averaged 7.6 inches in March, 1939. Many

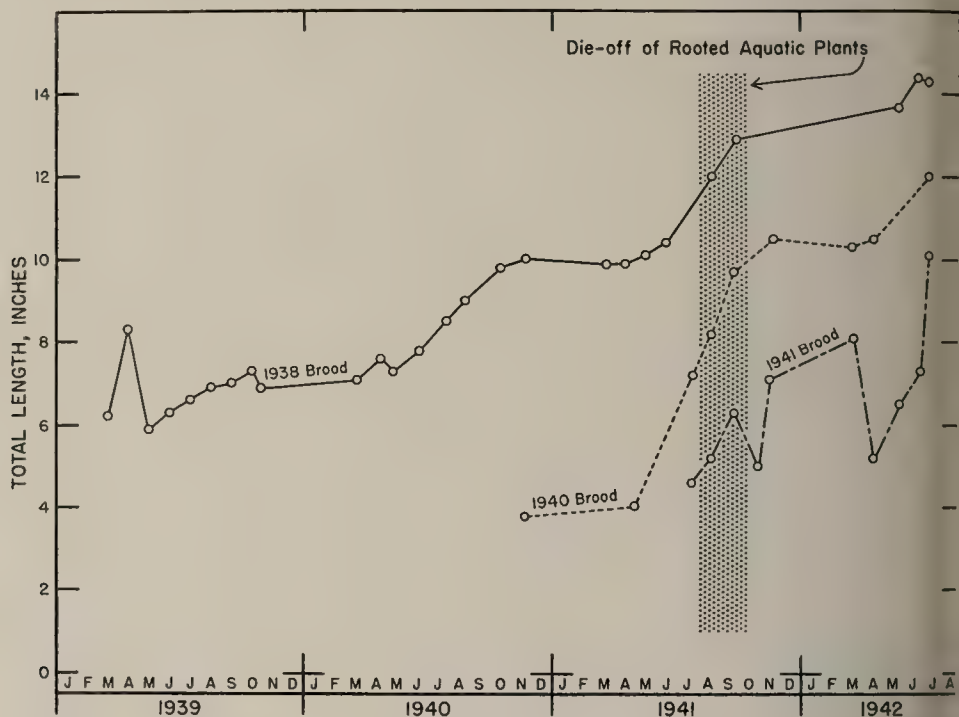


Fig. 6.—Average rates of growth of 1938, 1940, and 1941 broods of largemouth bass in Fork Lake.

average lengths of the various broods, figs. 6 and 7. Whenever possible, the broods of each species were separated by a study of scale patterns and counts of annuli. In a few cases, where fish were used for stocking other waters, no scales were taken. These fish were assigned to various broods on the basis of size.

The growth of the 1938 brood bass seined from Homewood Lake and stocked in Fork Lake on June 23, 1938, was at first very rapid. When released these bass fry averaged 0.87 inch, and 74 of them caught in October, 1938, averaged 6.45 inches total length (Thompson & Bennett 1939a). One hundred sixty-one were col-

lected and preserved between late June and mid-September, 1938.

A number of fish were taken by angling and minnow seining in 1938 as a means of following growth rates of the two species. 161 bass, 2 adult bluegills, and 34 of the 1938 brood bluegills. Thus, when systematic cropping was begun in March 1939, the original fish population had been reduced to a figure that did not exceed 1,279 bass and 268 bluegills. Throughout the period of study only 866 bass and 19 bluegills of the original stock were recaptured.

In 1939, the bass increased in length very little, presumably because so many bass were present in the pond that the available food supply was inadequate for their requirements. Bass collected in

7, which may denote some growth, although this is largely obscured by a considerable variation in sizes (and ages) of individuals trapped. As male bluegills usually average larger than females for

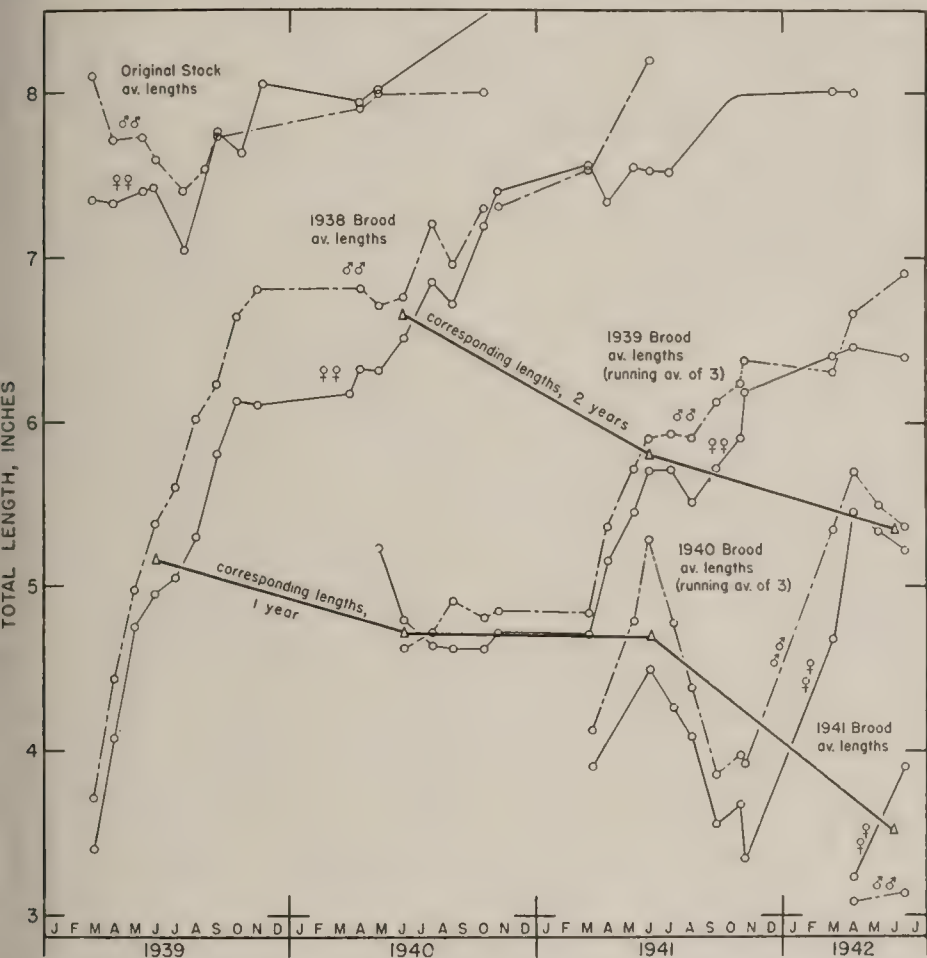


Fig. 7.—Average rates of growth of original stock and the four broods of bluegills spawned in Fork Lake, 1938–1941. As males usually average larger than females, the curves representing the sexes are separated. Corresponding average lengths of fish of the several broods at 1 and at 2 years of age are indicated to show the decrease in growth rate throughout the period of sampling.

March averaged 6 inches. A number of "cannibals" (Cooper 1937) collected in April materially raised the average length for that month; the average length of bass taken in October was only 7 inches, fig. 6. The original bluegills, with an indicated average length of about 7.5 inches by the fall of 1938, showed a fluctuation in average length of fish caught during 1939, fig.

any given age, points representing the average lengths of males and of females in fig. 7 are separated.

The growth of the 1938 brood bluegills was rapid in 1939, fig. 7; fish taken from the pond averaged 3.5 inches in March and nearly 6.5 inches in October. The indicated increase in average size of these bluegills between March and April, 1939,

may not have been due entirely to growth; it is presumed that many of the smaller fish of this brood were eaten by bass at this time and so were unavailable to influence the average lengths of later collections. This assumption is substantiated by the appearance of annuli on the scales of the 1938 brood bluegills. The annuli appeared largely between the April and May collecting periods (Bennett, Thompson, & Parr 1940, fig. 6) and were believed to mark the resumption of growth in the spring.

The large number of bass fry used in stocking the pond reduced the numbers of the 1938 brood bluegills to a point where those that escaped capture made excellent growth in 1939. Yet the increase in size of the bass increased their own food requirements to such an extent that the spawn of the remaining original bluegills plus that of the now sexually mature 1938 brood could not furnish sufficient food for the bass. This situation resulted partly because bass raided the bluegill nests and ate the newly hatched fry before they attained a substantial size. Thus, in 1939, growth conditions in Fork Lake were favorable for bluegills too large for bass to eat (above 3.5 inches in length) but were unfavorable for bass.

Similar conditions obtained in the early part of the 1940 growing season, although the number of bass had been reduced by 349, more than half (162 of 268) of the original bluegills had been taken, and 773 of an unknown number of 1938 brood bluegills had been netted and removed in 1939. The bass showed little growth in the first 3 collecting months. After the advent of the 1940 spawning season, when both young bass and young bluegills were available for food, the average lengths in the 1938 brood bass collections increased from about 7 to 10 inches.

Bluegills of the original stock and the 1938 brood continued to grow at a satisfactory rate in 1940. The number of the original stock taken was small (27) and lengths varied as in 1939. Bluegills of the 1938 brood, which averaged about 6.5 inches at the beginning of the 1940 growing season, averaged about 7.4 inches by November. Four hundred twenty-seven of the 1938 brood were taken in 1940 and, as in 1939, this brood made up the bulk of the bluegill crop. A few 1939 brood

bluegills were taken in October, 1939; they appeared again in nets in May and June, 1940, and were present in all later collections. The average size of the members of this brood in collections did not increase during the season. This lack of size increase was due probably to net selectivity; that is, the collections of early months contained only the larger fish of this brood. Two hundred forty-six bluegill fry of the 1940 brood were taken during the summer and most of these were used to stock other ponds.

By March, 1941, 718 of the 1,440 original stock of bass had been recaptured; many more had probably been lost through cannibalism and other causes. The remaining bass made little growth during the spring and early summer months of 1941.

The 1940 brood bass, the first brood spawned in the pond, appeared in the November collection of that year; the average length of 8 of these was 4.0 inches as compared with an average length of 6.45 inches for 74 of the 1938 brood bass at the end of their first season of growth. Few of the 1940 brood bass were taken until the latter part of July, 1941, when those collected averaged 7.2 inches in length. The plant die-off early in August left small bass and small bluegills without the protection of the mats of vegetation. In the next 3 months, August through October, the increase in average lengths of bass collected indicated that individuals of all broods made remarkable growth. In the collections, the 1938 brood bass averaged less than 10.5 inches in June and 13.0 inches in October; the 1940 brood, 7.0 in June and 10.5 inches in October; and the 1941 brood (spawned that season) nearly 6.5 inches in October.

By 1941 the original and the 1938 brood bluegills were becoming scarce. Only 2 of the original and 35 of the 1938 brood bluegills were taken in that year. Bluegills of the 1939 brood, which made up the bulk of the 1941 bluegill catch, were less numerous and averaged so much smaller in size than the 1938 brood when of comparable age that the total weight of the 1941 bluegill crop was less than half of that of the 1940 crop, table 5. The 1939 brood bluegills collected averaged about 4.8 inches in March of 1941 and 6.3 inches at the end of the growing season.

The sizes of individuals in the collections of 1940 brood bluegills in 1941 varied over a large range, and the growth curve as plotted in fig. 7 shows a continuous decrease in average length from a high in June to a low in November. This decrease was due in part to the selectivity of nets; early in the season the nets held only the largest members of the brood, which were few in number, while later the more numerous smaller members had grown large enough to be held by 1-inch mesh. The average length of these second-year fish in June was 4.7 and in October–November 3.8 inches. Although 145 of these fish were taken in 1941, their combined weight was only 5.5 pounds.

The average sizes of bluegills taken during and after the plant die-off of August, 1941, showed no increase comparable to that found in bass, and it must be assumed, therefore, that no comparable improvement in bluegill food supply resulted from the "bloom" of algae that followed the *potamogeton* die-off.

Relatively few bass were taken in the March–June collecting period of 1942 but, of the fish collected after the wash-out, 34 bass of the original stock averaged 14.2 inches and 1.76 pounds at 4 years; 4 of the 1940 brood, 12 inches and 1.17 pounds at 2 years; and 16 of the 1941 brood, 10 inches and 0.79 pound at 1 year. The large size of the bass of the 1940 and 1941 broods was due largely to growth made during the plant die-off period of 1941.

Four broods of bluegills were represented in the 1942 collections: 7 bluegills of the 1938 brood averaged 8.0 inches at 4 years; 35 of the 1939 brood, about 6.6 inches at 3 years; 193 of the 1940 brood, about 5.5 inches at 2 years; and 18 of the 1941 brood, about 3.5 inches at 1 year. Bluegill growth was consistently poorer with each successive year, fig. 7, in spite of heavy cropping. This slow growth rate is believed to have resulted from a reduction in the available food supply associated with the spread of the plant, *Potamogeton foliosus*.

Condition and Growth

Condition, or relative plumpness, of fish is a measurement of some value in pond management. A high average condition

usually indicates an abundance of available food in relation to the number of fish present, and a low average condition denotes slow growth and undue food competition.

The index figure indicating condition of bass and bluegills, as calculated by any of several recognized formulas, increases with an increase in the length of the fish even for fish apparently of the same relative plumpness. The form of both bass and bluegills changes somewhat throughout their length range.

In this manuscript the Index of Condition formula (Thompson & Bennett 1939*b*) has been used:

$$\text{Index of Condition} = \frac{W}{L^3} \cdot \frac{10,000}{L^3}$$

W represents weight to the nearest hundredth pound, and L represents total length to the nearest tenth inch.

When this formula is used on lengths and weights of bass within the length range of 5 to 15 inches, an Index of Condition figure of 3.5 to 4.5 denotes a fish in poor flesh; 4.6 to 5.5, one of about average or normal plumpness; and 5.6 to 6.5, a very fat fish.

In bluegills, the increase in index figure with increasing size is more pronounced than in bass, but in fish of 5 to 8 inches an Index of Condition figure of 7.0 or below denotes a fish in poor flesh; 7.1 to 8.0, one of normal or average plumpness; and above 8.0, one of unusual plumpness.

The condition curve for 1938 bass in 1939, plotted in fig. 8, shows that fish of this brood were within the range of normal condition during April, May, and June, then dropped into the thin classification, and remained there until July, 1940. This period coincides with the period of very small length increase (March, 1939–June, 1940) cited above in the discussion of growth. After the bass and bluegills had spawned in 1940, bass of the 1938 brood began to grow, and their condition curve rose gradually to 5.0 and slightly above. These bass remained within the range of normal plumpness until the period of vegetation die-off and "bloom," when they became very fat and their condition curve rose rapidly to 6.15. A drop to normal followed, but in 1942 the condition curve of the 1938 brood again rose above 6.0. The spectacular rise in the condition curve of bass of the 1938 brood dur-

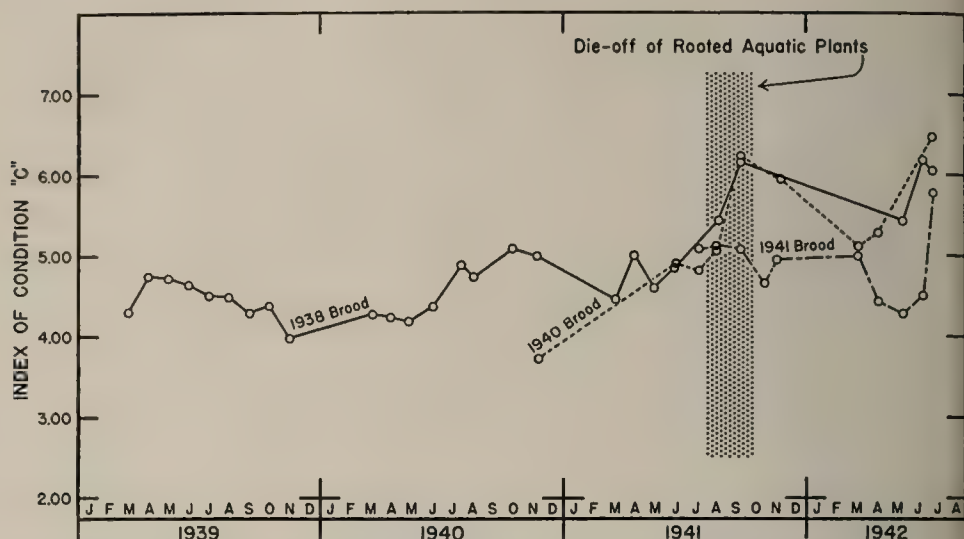


Fig. 8.—Average Indexes of Condition of the 1938, 1940, and 1941 broods of bass in Fork Lake, 1939–1942. An Index of Condition of 3.5 to 4.5 denotes a fish in poor flesh; 4.6 to 5.5, about average or normal; and 5.6 to 6.5, very fat.

ing the “bloom” of 1941 is paralleled by a similar rise for bass of the 1940 brood, and in each brood the rise is followed by a drop in the late fall and early spring following and a rise with the last collections of 1942.

Bass of the 1941 brood appeared in the catch about the time of the “bloom” and showed less influence from it. However, these bass were much smaller than the members of the other broods, and their Index of Condition of 5.10 is considered

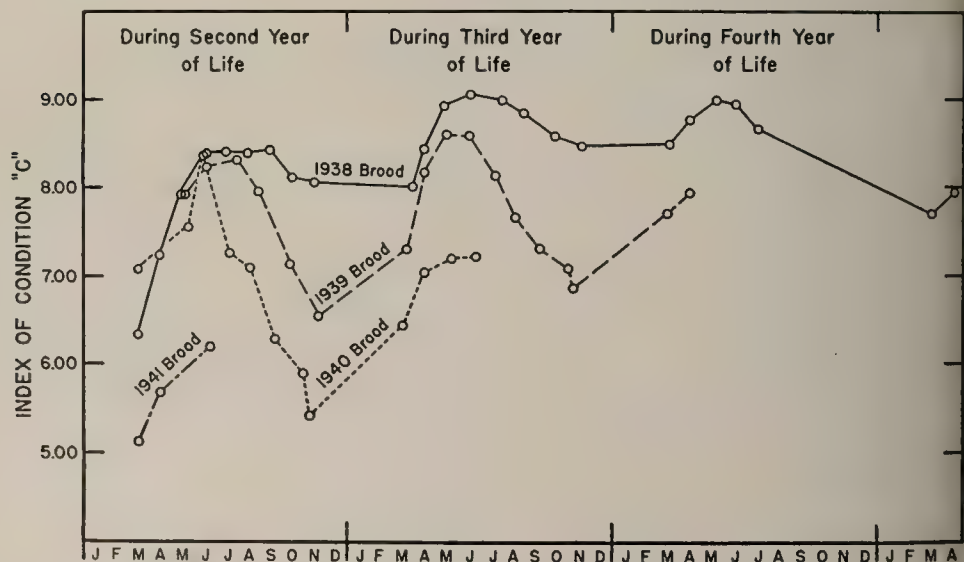


Fig. 9.—Average Indexes of Condition of the several broods of bluegills spawned in Fork Lake, 1938–1941, arranged to show average condition of these fish at comparable ages. The condition cycle of bluegills in Fork Lake is characterized by a high in May and a low in November. Bluegills with a condition factor of 7.0 or below are thin; those with a factor of 7.1 to 8.0 are normal or average; and those above 8.0 are unusually plump.

high. The early spring collections of 1942 showed a marked drop in Index of Condition of the 1941 brood, but improvement to 5.77 in early July.

As bluegills showed no increase in length or improvement in condition coinciding with the 1941 plant die-off, condition curves for bluegills are plotted to show comparable conditions of the several broods of bluegills at comparable ages, fig. 9. Throughout the period of study (except for the first few months when the fish were very small) the average condition for the 1938 brood bluegills was highest in early summer, but the curve remained always above 8.0, indicating that the fish were unusually plump. Other broods showed a rise in condition during the spring months to a point above 8.0, followed by a severe drop in or after July to a low in November. The drop was much more pronounced in the 1939 and 1940 broods than in that of 1938. A regular cycle of condition, probably influenced by spawning, seems to be characteristic of this species. The cycle reaches a high in early summer and a low in late fall. The fluctuations in the bluegill cycle must be considered when judging the condition of bluegills from a selected body of water on the basis of a single collection.

Scale Analysis

Annual rings, or annuli, that appear on fish scales are used frequently by aquatic technicians to determine age of fish. The validity of this practice has been tested for only a few species, although fisheries biologists, including the author, have applied the practice of "scale reading" to many species of fresh-water fishes.

This study of bass and bluegills in Fork Lake gave a good opportunity to determine the validity of the scale method of age determination in these species, particularly in the original bass stocked as fry in 1938 and in the 1938 brood bluegills. As the original bass fry did not become sexually mature in 1939, no new brood of bass appeared until June, 1940, so that throughout the period of study the original bass could be separated from the 1940 and 1941 broods on the basis of size. The 1938 brood bluegills grew rapidly during their first 2 years (1938-1939) in the pond; this rapid growth, and the fact that body

length, weight increases, and scale growth were followed from month to month throughout the growing seasons of 1939, 1940, 1941, and a part of 1942, gave assurance as to the correct identification of this brood in all collections.

In a previous study of the scales of Fork Lake bass and bluegills collected in 1939 (Bennett, Thompson, & Parr 1940), the annuli were found to appear on the scales at about the time growth was resumed following a period of dormancy (winter). The length of the period during which individual fish of a given brood were in the process of forming annuli seemed to depend upon the amount of food available for that species of fish within the brood size range at the beginning of the growing season. If acceptable food was abundant, the beginning of growth was controlled by the temperature of the warming water, and most of the fish began to grow at about the same time. The appearance of the annulus, being dependent upon the addition of concentric ridges of new material (circuli) on the scale margins, was closely associated with a length increase of the fish body. If acceptable food was relatively scarce at a time when temperature conditions were favorable for rapid growth, the beginning of body growth within a brood of fish was delayed until the individual members were able to ingest a quantity of food in excess of body maintenance requirements, and annulus formation was prolonged over a much greater period than when food was abundant. There is no evidence to indicate that the annuli on the scales of warm-water fishes are more than visible marks produced by alternate periods of scale growth and growth stoppage. While the cessation of body growth and scale growth of fishes in winter is the result of low water temperatures which reduce the rate of metabolism, conditions might occur during the growing season (summer) which would stop growth, and, if growth were resumed later, produce false annuli.

False annuli, which appeared on the scales of both the 1938 brood bass (original stock) and 1938 brood bluegills in mid-summer of 1939, were quite common (Bennett, Thompson, & Parr 1940). While these marks were indistinct on the scales of many fish, on others they were very definite and were indistinguishable

from true annuli formed earlier in the season. The identification of these clear marks as false annuli aroused questions as to the validity of the scale method of age determination. Therefore, it was important to determine the percentage of clear false annuli among the broods of bass and bluegills in Fork Lake. In the 1938 brood bluegills taken in 1939, 10.0 per cent had clear false annuli, formed in midsummer, that were in no way distinguishable from a true annulus. The false mark was in each case laid down outside of the first annulus (in the second summer of life). In the collections of 1940, 11.3 per cent of 329 fish of this brood (1938) showed a clear false annulus in the same position as those found in 1939, although in fish collected after May, when the 1940 annulus had formed, the false annulus lay between the first and second true annuli. In the collections of 1941, 5 of 35 fish (14.3 per cent) of the 1938 brood showed a clear false annulus in the same position. Thus, throughout the period of study, from 10.0 to 14.3 per cent of the 1938 brood bluegills collected each year showed a clear false annulus that formed during the summer of 1939 (outside the first true annulus). This false annulus was in no way distinguishable from the true annuli.

The scales of the 1938 brood bluegills were carefully checked for the presence of clear false annuli, other than those formed during the summer of 1939. Only 12 were found on fish collected in 1940 and later. These 12, located outside the second true annulus, appeared on the scales during the summer of 1940.

The 1939 and 1940 brood bluegills grew less rapidly than the 1938 brood and, while the exact identification of members of these broods is less certain than of members of the 1938 brood, monthly collections failed to show clear false annuli with any

degree of frequency. Table 8 gives the percentages of clear false annuli on the scales of 1939 and 1940 brood bluegills.

Clear false annuli were common on largemouth bass scales. About 6 per cent of the 1938 brood bass caught in 1939 showed a false annulus that might be confused with true annuli. In the 1940 collections of 1938 brood bass, 15.3 per cent of the fish showed a false annulus outside the first true annulus (false annuli formed in the summer of 1939). In the 1941 and 1942 collections of the same brood bass, false annuli were found on the scales of 6.9 per cent and 4.5 per cent, respectively. No distinct false annuli were found in the 1938 brood bass other than those that were formed during the summer of 1939, located between the first and second true annuli. No clear false annuli were present on the scales of either the 1940 or 1941 brood bass.

Other abnormalities associated with the scales of 1938 brood bass were found in this scale study. Some 1938 brood bass did not grow at all in 1939 and on the scales of these fish (three in number) the 1940 annulus replaced the annulus that should have appeared in the summer of 1939. Thus, these fish showed one less annulus than should have been present.

In nine other bass of the 1938 brood, the increase in length was very small in 1939. This small growth was reflected on the scales in an addition of only three or four circuli outside the 1939 annulus and these in only the anterior field of the scale. When the 1940 annulus formed, the interspace between it and the 1939 annulus consisted of the few circuli in the anterior field, and the two rings coincided in the lateral and posterior fields of the scale. Thus, a confusing partly double ring was formed, which probably would ordinarily be interpreted by a scale reader as a single

Table 8.—Percentage of clear false annuli observed on the scales of 1939 and 1940 brood bluegills in 1940, 1941, and 1942.

Brood	1940			1941			1942		
	Number of Fish	Number with False Annuli	Per Cent with False Annuli	Number of Fish	Number with False Annuli	Per Cent with False Annuli	Number of Fish	Number with False Annuli	Per Cent with False Annuli
1939..	312	6	1.9	336	8	2.4	35	0	0.0
1940..	—	—	—	129	1	0.8	194	4	2.1

annulus. In the scales of two other fish of this brood, the 1939 and 1940 annuli were entirely distinct, but so close together as to throw suspicion on their validity. None of these abnormalities was accompanied by serious scale erosion and none was found on the scales of 1940 and 1941 brood bass.

Most of the annulus abnormalities given above—false annuli, skipped annuli, overlapping annuli, and close spacing of annuli—were associated with the 1938 broods of bass and bluegills, and most of the abnormalities were laid down on the scales during the growing season of 1939.

During this period (1939), the 1938 brood bluegills were growing rapidly and the 1938 brood bass very slowly (see preceding section on growth). Later broods of bluegills were subjected to more competition for food (growth was less rapid) and later broods of bass were subjected to less food competition. Therefore, I am inclined to follow the theory that scale abnormalities as related to annulus formation are more common in fish growing at an abnormally rapid rate, or at an abnormally slow rate, than in those subjected to moderate food competition, resulting in "average" growth.

Some information on the way false annuli may arise on the scales of "wild" fish was gained through experiments in feeding fishes confined in aquariums. Bruno von Limbach (unpublished experiments at Urbana) attempted to feed individual bluegills (one fish to an aquarium) on a heavy diet of earthworms (8 to 10 per cent of body weight per day). These fish fed well and gained rapidly for a few weeks. Then for no apparent reason they went "off feed" and refused to eat their quota of worms. In some individuals, this condition persisted for several months, during which they continued to eat only enough to maintain their body weight. In others, heavy feeding was resumed after a "rest" of 1 or several weeks. In the latter fish, the periods of self-imposed starvation, followed by a resumption of feeding, produced false annuli on the scales. It cannot, of course, be proved that "wild" fish go "off feed" when food is abundant, but the possibility is worth considering.

In other experiments in which bluegills were forced to alternate between periods

of feeding and starvation, clear false annuli were produced on the scales if the starvation period between two 4-week periods of feeding was 3 or more weeks in length. Lesser periods of starvation produced inconspicuous false rings. It is conceivable that, under conditions of crowding in natural or artificial waters, individual fish might go practically without food for as long as several weeks, later to be supplied with comparatively large quantities of food from a hatch of aquatic insects or a spawn of young fish.

Skipped annuli, partly double annuli, and close spacing of annuli are easily explained as resulting from degrees of starvation extending throughout an entire growing season.

Spawning and Young Fish

No nests of largemouth bass were observed in Fork Lake during the period covered by this report. At the time of the dam failure, after all the water had drained from the pond basin, several craters were noted that may have been made by nesting bass in the spring of 1942. The nests of bluegills could be observed at almost any time during any summer and were most numerous in shallow water along the north shore of the pond near the spillway and on a submerged dome of earth at the east end between the forks. Nest-guarding males were nearly always present in these areas, where the nests of 5 to 10 inches in diameter were only a few inches apart, but more males were counted at the onset of the spawning season in May or early June than at any other period. Nesting males were least numerous on the spawning grounds from mid-June until the latter part of July. Later, the number of nest-guarding males increased.

In 1939, young bluegills were scarce, although bluegill nests were in use throughout the summer. The 1938 brood bass (stocked as fry) were then 6 to 10 inches long and on a number of occasions were observed to enter bluegill nests and feed upon bluegill fry in the yolk sac stage. No young bass were observed in 1939.

On May 27, 1940, 15 bluegill nests were counted in the spillway spawning grounds, fig. 10, and several thousand fry were schooling near these nests. The bass

fry stocked in 1938 became sexually mature in 1940 and, on June 3 of that year, 11 schools of fry were counted. Throughout the summer both young bluegills and young

20, five large schools of bass fry were counted, each containing several thousand fish. On July 19, schools of small fish—both bass and bluegills—were everywhere



Fig. 10.—A group of bluegill nests near the spillway of Fork Lake. These nests were exposed by low water levels during August, 1940.

bass could be seen amidst the submerged vegetation.

The 1940 broods of bass and bluegills made poor growth in their first year, and many small bluegills were in evidence in the early spring of 1941. When nets were lifted on March 22, 1941, "showers" of small bluegills "rained" through the meshes and fell back into the pond. On April 15, 76 small bluegills were trapped, as a net was lifted, by a mat of *Spirogyra*. These fish averaged 1.48 inches long; the largest were 2.0 inches.

Nineteen bluegill nests containing eggs were seen on May 6, 1941, and, on May

along the edge of the pond in the fine-leaved potamogeton. When nests were raised on September 24, small bluegills and bass dropped through the meshes; most of the bass were less than 3 inches long and the bluegills less than 2 inches. Their numbers seemed scarcely less than in July, although all rooted submerged vegetation had disappeared in early August.

In 1942, the spawning season was unusually late, due to a cold, wet spring, and neither young bass nor young bluegills were seen as late as May 26. The first schools of bass were observed on June 2;

on this date 17 bluegill nests were found to contain eggs, but no bluegill fry were then in evidence. Throughout June the young of both species were again very numerous.

Each year of the Fork Lake study, with the exception of 1938 and 1939 when no mature bass were present, large numbers of young bass and bluegills were to be found in the pond. A minnow seine haul along the shore any time after June would have taken large numbers of both species.

Swingle (1945) recommended minnow seining in ponds as a method of testing the "balance" of a bass-bluegill population. The presence of the young of both species in such seine hauls was said to indicate that the fish population of the pond was in "balance" and the pond should produce good fishing. While the adult bass and bluegills in Fork Lake produced a successful spawn each year (1940-1942), this spawn production bore little relationship to the annual fish yield, average sizes of adult fish in the pond, or the catch of fish per man-hour.

It indicated, however, that the adult population of fish was not crowded to the extent that reproduction in either species was curtailed.

Sexual Cycle

In the process of determining by dissection the sex of largemouth bass and bluegills from Fork Lake, it was noted that changes in the appearance of the ovaries and testes occurred that could be readily identified. In immature fish of both species, the sex was easily told, although the sex organs were often very small. In these fish, the ovaries were spindle shaped and granular, while the testes were almost threadlike. In late fall and early spring the gonads of the larger adult fish resembled those of the smaller immature fish, except that they were larger. As the spring advanced, the gonads of mature fish began to swell and change in shape and color, until in May these organs reached a maximum size, and soon after the reproductive products were ready for deposition. At this stage the ripe males would give off milt when gently pressed in the lower abdomen and females would pass eggs that were translucent, yellow, and sticky. After the spawning period, the

ovaries and testes appeared smaller and flabby, and pink or red with blood. In the fall the gonads again would assume an immature appearance.

In order to identify these changes with time in both species, a brief description of the stages was formulated. The classification given below was published in a previous Fork Lake report (Bennett; Thompson, & Parr 1940):

Immature. Testes slender, translucent cords; ovaries small, translucent, and grayish pink.

Poorly developed. Testes slightly enlarged, opaque, and white; ovaries somewhat enlarged, opaque, pale yellow, and developing eggs with a granular appearance.

Enlarged. Testes greatly enlarged, flattened, with wavy edges, opaque, and white; ovaries greatly enlarged, oval with large, distinct, solid, opaque, yellow eggs.

Spawning condition. Testes as above, but giving off milt when gently pressed; ovaries as above, but turgid, giving off eggs when gently pressed. Eggs semiliquid, translucent, yellow, and sticky.

Partly spent. Testes (after May) same as next above but less swollen; ovaries smaller, but very similar to conditions described as enlarged.

Completely spent. Testes small and pinkish; ovaries flabby at first, contracted later, pinkish, with granular appearance.

The divisions of this classification, while intergrading from one to another, were distinct enough for practical use. However, it was unknown what these stages represented microscopically and whether the classification was valid on a histological basis.

In order to determine the validity of the above classification and to answer other questions associated with reproduction in Fork Lake bass and bluegills, a histological study was begun in 1940 by Dr. Marian F. James (1946). From March, 1940, until July, 1942, gonads of 742 bluegills and 218 bass were removed from Fork Lake fish (samples every month except December, January, and February) and turned over to Dr. James for study. Supplementary gonads from bass of known ages were obtained from Ridge Lake near Charleston in east-central Illinois and from Lake Glendale near Robbs in southern Illinois.

A histological study of these gonads shows a well-founded basis for the macroscopic classification in both bass and bluegills. None of the larger 1-year-old bass from Fork Lake or Lake Glendale was sexually mature, and, although a few of the larger male bass that were hatched in Ridge Lake in May, 1941, developed small numbers of sperms in May, 1942, none of the female bass produced mature eggs. Many of these yearling bass were more than 10 inches in length and weighed 0.5 to 0.6 pound.

The larger and medium-sized 1-year-old bluegills from Fork Lake produced mature eggs or sperms, but those less than 2 inches long collected during the spawning season contained only small oocytes, indicating that they were sexually immature.

The time schedule of the sexual cycle of bluegills in 1940 was essentially the same as in 1939. Gonads of about 90 per cent of the bluegills examined were "poorly developed" in the period March 14-25; some were classified thus as late as August 19-22. "Enlarged" gonads were collected from April 12 to July 23; the higher percentages were in April, May, and June. Gonads in "spawning condition" first appeared May 20 and were present in the August 19-22 collections but not later. "Partly spent" testes first appeared June 13-19, and "partly spent" ovaries, July 17-23; no partly spent ovaries or testes appeared after September. Four per cent of the testes were "completely spent" June 13-19; only 58 per cent of the testes and 80 per cent of the ovaries were completely spent September 17-24. Gonads of all bluegills collected during the latter part of October and early November were completely spent and were in advanced reorganization stages (spermatogonia and small oocytes). Each year during the reorganization period, which followed after the completion of spawning, the spermatogonial cells and oocytes that became the spermatozoa and eggs for the next season were differentiated.

The timing of the sexual cycle in bass was a little in advance of that of bluegills. In the March 14-20 collecting period, 100 per cent of the gonads of 2-year-old bass were in the "enlarged" stage. In the May 6-26 collections, 27 per cent of the testes

were in "spawning condition," and 73 per cent were "partly spent," while 67 per cent of the ovaries were "enlarged," 25 per cent in "spawning condition," and 8 per cent "partly spent." No sexually mature bass were taken in June or July, but those taken in August or later contained reorganized gonads.

These studies indicate an intermittent spawning season for bluegills, in 1940 beginning the latter part of May and lasting through September. The bass spawning season was confined to May, beginning probably a little earlier than that of the bluegills. Field observers often recorded schools of young bass in Fork Lake by the time the bluegills were guarding eggs. In both species the males appeared to come into spawning condition a little before the females.

The histological study of James (1946) offers conclusive evidence that in Illinois bluegills mature at 1 year and bass at 2 years; some of the larger bass males produced a few sperms as yearlings. In the South, according to Swingle & Smith (1943), bluegills may reproduce at 4 months under unusually favorable conditions, but normally not until 1 year of age; bass commonly reproduce at 10 to 12 months unless stunted. These differences in the ages at which the two species reach sexual maturity in the North and in the South must be considered in stocking new ponds with bass and bluegill fry.

Foods

Stomachs for food analysis were collected from Fork Lake bass and bluegills during 1939, 1940, and 1941. In 1941, the collections of bluegill stomachs were discontinued after May, but those of bass were continued throughout that season. The numbers of fish stomachs containing food taken through the months of collecting during these years were as follows: bluegills, 671 in 1939, 504 in 1940, 108 in March, April, and May, 1941; bass, 299 in 1939, 175 in 1940, 121 in 1941. As the stomachs were removed from the fish, each stomach was given an accession number and preserved in alcohol. Corresponding accession numbers on the scale envelopes made it possible to relate the stomachs to fish of known ages, lengths, and weights. Methods of determining

volume of stomach contents were those described in a previous Fork Lake report (Bennett, Thompson, & Parr 1940).

Although, in the years of this study the most pronounced change in the pond environment was caused by the gradual spread of *Potamogeton foliosus*, other less obvious changes may have affected the relative abundance of fish foods during the period of this study. No quantitative samples of aquatic invertebrates were made, and therefore changes in abundance of these animals were unrecorded except as indicated by field observations and stomach analyses.

Fluctuations in the numerical abundance in individual broods of bass and bluegills in Fork Lake probably affected the degree of food competition at various times during the $3\frac{1}{2}$ years of study. The degree of competition for a "staple" food often determines whether an individual fish is able to select this in preference to some less satisfactory substitute. Two species of fish that compete but little for food in a favorable aquatic environment may, under crowded conditions, be forced to change their normal feeding habits and become highly competitive.

In 1938, after the pond was restocked with adult bluegills and bass fry, there was apparently little competition for food, as indicated by the growth of the stocked fish and the 1938 spawn of the bluegills.

It is likely that in March, April, and May of 1939 some of the smaller bluegills of the 1938 brood were still available for bass food, although bass stomachs collected in March did not contain any fish (Bennett, Thompson, & Parr 1940). Small bluegills were observed in the fall of 1938. Also, the increase from March to April, 1939, in the average lengths of 1938 brood bluegills collected, fig. 7, hardly can be explained as growth, because of low water temperatures at that period; rather this length increase in the collections suggests the elimination of the smaller individuals of the brood. In March, bass stomach contents consisted of 80 per cent water boatmen and back swimmers, 4 per cent aquatic beetle larvae, 15 per cent terrestrial insects, and 1 per cent insect fragments. In April, fish and crayfish made up a total of 37 per cent of the diet, Entomostraca—largely *Daphnia*—25 per cent, and water boatmen, back swimmers, aqua-

tic beetle larvae, and insect fragments the remaining 38 per cent. In May, fish and crayfish constituted 18.2 per cent of the diet. Other items, in addition to a trace of snails and coarse aquatic plants, consisted of insects, of which more than 25 per cent were adults—mostly dragonflies, damselflies, and midges. The extensive use of insects during this period indicates a scarcity of fish and crayfish of sizes that could be handled by 6-inch bass.

During the spring period of 1939, the bluegills of the original stock and the 1938 brood fed heavily on Cladocera, midge larvae, and snails; other aquatic insects were somewhat less important in the diet. Competition between bass and bluegills for any single group of insects was not obvious, but bass made wide use of the varieties of insects available. The nest robbing activities of bass on the bluegill spawning ground, mentioned previously, indicate the extent of the shortage of bass foods. In the collections of July, 1939, very small bluegills made up 51.4 per cent of the bass diet, but the figure dropped to less than 30 per cent in August and September and less than 10 per cent in October. Both bass and bluegills depended upon aquatic insects (mostly larval) during the latter part of the 1939 collecting season—feeding most heavily on Diptera larvae and water boatmen.

In 1939 the competition for insects between these two species of fish had no appreciable effect upon the growth rate of either the original or 1938 brood bluegills, fig. 7. Cladocera and midge larvae were more or less staple foods for the small-mouthed bluegills, but apparently Cladocera and aquatic insects were not conducive to rapid growth in bass.

In 1940, when aquatic vegetation began to appear in Fork Lake in abundance, stomach collections taken from March through June were largely from bass and bluegills of the 1938 broods, table 9. In March and April, both species fed largely on midge larvae, and the quantity of fish and crayfish in bass stomachs was insignificant. In May only one bass stomach was obtained and it contained 95 per cent crayfish. Contents of the bluegill stomachs collected in May consisted of *Daphnia* (50 per cent of the total), insects, and a few miscellaneous items; Diptera larvae constituted nearly 21 per cent of the total.

Table 9.—Results of stomach analyses of bass and bluegills taken from Fork Lake in 1940. In the columns designating types of food, figures not in parentheses represent percentages of total weight of stomach contents; figures in parentheses represent frequencies of occurrence on the basis of 100 stomachs.

MONTH AND GROUP OF FISH	NUMBER OF STOMACHS		TOTAL FOOD, GRAMS	DIPTERA		EPHEMERIDA		TRICHOPTERA LARVAE	DAMSELFLIES	
	Empty	With Food		Larvae	Adults	Nymphs	Adults		Nymphs	Adults
<i>March</i>										
1938 Bass.....	1	52	45.254	57.8 (100)	—	1.8 (27)	—	—	3.2 (40)	—
1938 Bluegills.....	0	10	8.500	95.8 (100)	—	0.2 (10)	—	—	1.4 (40)	—
<i>April</i>										
1938 Bass.....	3	40	35.370	71.9 (100)	0.4 (5)	—	—	—	1.4 (18)	—
1938 Bluegills.....	11	79	35.758	43.6 (89)	—	0.6 (6)	—	—	1.0 (8)	—
<i>May</i>										
1938 Bass.....	1	1	1.500	—	—	—	—	—	—	—
1938 Bluegills.....	2	83	27.658	20.8 (61)	—	1.3 (8)	—	0.3 (4)	—	—
<i>June</i>										
1938 Bass.....	0	11	11.432	—	—	—	—	0.5 (9)	19.1 (46)	—
1938 Bluegills.....	0	7	1.842	61.5 (71)	—	—	—	6.3 (43)	—	—
<i>July</i>										
1938 Bass.....	0	1	0.750	35.0 (100)	—	—	—	—	35.0 (100)	—
1938 Bluegills.....	0	5	2.015	16.6 (60)	—	—	—	2.5 (40)	—	—
1939 Bluegills.....	0	29	10.867	46.6 (83)	—	0.6 (7)	—	5.3 (41)	2.7 (24)	—
<i>August</i>										
1938 Bass.....	5	34	13.738	0.6 (6)	—	—	—	—	1.8 (6)	—
1938 Bluegills.....	1	7	3.330	30.2 (7)	—	1.8 (14)	—	1.5 (14)	2.3 (14)	—
1939 Bluegills.....	1	45	17.140	32.5 (76)	—	0.3 (4)	—	5.6 (36)	1.2 (13)	—
<i>October</i>										
1938 Bass.....	1	19	10.741	tr. (11)	—	—	—	—	0.5 (5)	—
1938 Bluegills.....	1	23	9.239	26.2 (74)	—	—	—	—	2.8 (13)	—
1939 Bluegills.....	9	110	35.849	25.6 (69)	—	1.0 (13)	—	1.2 (16)	7.5 (31)	—
<i>November</i>										
1938 Bass.....	2	9	8.716	—	—	—	—	—	3.9 (11)	—
1940 Bass.....	1	7	0.973	tr. (14)	—	—	—	—	16.4 (29)	—
1938 Bluegills.....	0	3	2.200	32.5 (100)	—	8.6 (67)	—	3.5 (67)	3.6 (33)	—
1939 Bluegills.....	2	90	28.319	45.3 (32)	—	4.5 (28)	—	2.6 (22)	9.2 (43)	—

Table 9 (continued)

MONTH AND GROUP OF FISH	ENTOMOSTRACA			MOLLUSCA		COARSE AQUATIC PLANTS	ALGAE	WATER MITES	SAND AND SCALES	MISCEL- LANEOUS
	Daphnia	Cyclops	Cypris	Snails	Sphaeriids					
<i>March</i>										
1938 Bass.....	—	—	tr. (4)	—	—	tr. (2)	—	—	—	—
1938 Bluegills.....	2.5 (90)	—	—	—	—	—	—	—	—	—
<i>April</i>										
1938 Bass.....	tr. (5)	—	tr. (3)	—	—	—	—	—	—	—
1938 Bluegills.....	28.7 (75)	tr. (1)	tr. (3)	0.2 (3)	—	—	—	—	—	—
<i>May</i>										
1938 Bass.....	—	—	—	—	—	—	—	—	—	—
1938 Bluegills.....	50.0 (73)	—	—	2.2 (16)	—	1.5 (8)	tr. (1)	—	—	1.4 (16)
<i>June</i>										
1938 Bass.....	—	—	—	—	—	1.0 (18)	—	—	—	0.5 (18)
1938 Bluegills.....	—	—	—	3.1 (29)	—	1.3 (29)	1.0 (14)	—	—	2.7 (43)
<i>July</i>										
1938 Bass.....	—	—	—	—	—	—	—	—	—	—
1938 Bluegills.....	—	0.3 (40)	—	10.7 (20)	—	—	—	—	—	—
1939 Bluegills.....	—	1.4 (38)	—	4.3 (34)	—	0.4 (14)	1.8 (14)	tr. (3)	—	2.5 (40)
<i>August</i>										
1938 Bass.....	—	tr. (3)	—	6.3 (24)	—	1.4 (12)	0.6 (3)	—	—	tr. (3)
1938 Bluegills.....	—	—	—	25.4 (86)	—	0.5 (14)	7.3 (29)	—	—	0.3 (14)
1939 Bluegills.....	—	2.6 (31)	—	9.2 (40)	—	8.3 (24)	3.2 (22)	—	—	6.5 (29)
<i>October</i>										
1938 Bass.....	2.6 (5)	0.5 (5)	—	0.9 (5)	—	—	2.6 (16)	—	—	tr. (5)
1938 Bluegills.....	8.1 (30)	3.0 (17)	3.7 (30)	24.7 (65)	—	2.5 (22)	7.4 (43)	—	—	1.0 (30)
1939 Bluegills.....	17.5 (53)	5.3 (54)	0.9 (18)	8.5 (37)	—	2.0 (14)	9.4 (44)	—	—	0.5 (17)
<i>November</i>										
1938 Bass.....	—	—	—	—	—	—	0.7 (22)	—	—	—
1940 Bass.....	tr. (14)	—	—	—	—	—	—	—	—	—
1938 Bluegills.....	35.0 (100)	2.3 (33)	6.4 (33)	2.3 (33)	—	—	1.4 (33)	—	—	—
1939 Bluegills.....	28.1 (96)	2.4 (57)	2.4 (29)	0.9 (10)	—	—	2.0 (22)	—	—	tr. (2)

Table 9 (concluded)

MONTH AND GROUP OF FISH	DRAGONFLIES		WATER BOATMEN	WATER STRIDERS	AQUATIC BEETLES		TERRES- TRIAL INSECTS AND WORMS	INSECT FRAG- MENTS	FISH	CRAYFISH
	Nymphs	Adults			Larvae	Adults				
<i>March</i>										
1938 Bass.....	33.0 (62)	—	2.8 (21)	—	—	—	0.5 (2)	—	—	0.9 (2)
1938 Bluegills.....	—	—	—	—	—	—	—	—	—	—
<i>April</i>										
1938 Bass.....	4.0 (13)	—	5.1 (28)	tr. (3)	—	0.5 (3)	2.5 (20)	7.9 (35)	3.7 (5)	2.5 (3)
1938 Bluegills.....	—	—	—	—	tr. (1)	tr. (1)	—	25.6 (53)	—	—
<i>May</i>										
1938 Bass.....	—	—	—	5.0 (100)	—	—	—	—	—	95.0 (100)
1938 Bluegills.....	—	—	tr. (4)	—	tr. (1)	—	tr. (1)	21.9 (45)	—	—
<i>June</i>										
1938 Bass.....	21.7 (36)	—	10.2 (18)	2.5 (64)	—	—	—	18.9 (27)	—	25.6 (36)
1938 Bluegills.....	—	—	—	—	—	—	—	24.2 (43)	—	—
<i>July</i>										
1938 Bass.....	—	—	—	—	—	—	—	30.0 (100)	—	—
1938 Bluegills.....	—	—	—	—	—	—	—	67.5 (80)	—	—
1939 Bluegills.....	0.4 (7)	—	—	0.2 (3)	12.6 (24)	—	—	23.7 (69)	—	—
<i>August</i>										
1938 Bass.....	3.5 (9)	—	—	1.2 (3)	—	—	—	6.7 (9)	73.5 (85)	3.9 (6)
1938 Bluegills.....	6.0 (14)	—	—	—	—	—	—	24.8 (71)	—	—
1939 Bluegills.....	2.0 (2)	—	tr. (2)	tr. (2)	3.2 (22)	—	0.4 (2)	24.7 (73)	—	—
<i>October</i>										
1938 Bass.....	6.8 (11)	—	tr. (5)	—	—	—	—	3.4 (11)	81.2 (90)	—
1938 Bluegills.....	4.3 (4)	—	—	tr. (4)	—	—	—	16.1 (57)	—	—
1939 Bluegills.....	1.2 (5)	—	tr. (5)	—	0.4 (5)	—	1.1 (8)	17.7 (45)	—	—
<i>November</i>										
1938 Bass.....	—	—	—	—	—	—	—	3.2 (11)	88.3 (100)	3.9 (11)
1940 Bass.....	—	—	—	—	—	—	—	14.3 (14)	69.0 (71)	—
1938 Bluegills.....	—	—	—	—	—	—	—	4.5 (33)	—	—
1939 Bluegills.....	tr. (1)	—	—	—	0.9 (10)	—	—	0.5 (3)	1.2 (1)	—

The large spawn of both bass and bluegills in late May and early June, 1940, probably improved the food situation for bass, although the heavy stand of aquatic vegetation offered excellent protection for young fish. The growth curve for 1938 brood bass indicates that most of the length increase occurred after June, fig. 6. In contrast to the spring diet of bass, which was largely insects, the late summer and fall diet consisted of more than 70 per cent fish, many of which were young bass. Other items of importance were crayfish, snails, and miscellaneous aquatic insect larvae. Diptera larvae were commonly found in the stomachs of bluegills of all sizes throughout 1940, and entomostracans were important from March through May and in October and November. Except that smaller numbers of *Corixa* and *Notonecta* were taken in 1940 than in 1939, bluegill foods were essentially the same in the 2 years. The 1939 brood bluegills grew less rapidly in 1940 than the 1938 brood when of comparable age (during 1939), fig. 7.

At the beginning of 1941, Fork Lake contained two broods of bass (1938 and 1940) and three broods of bluegills (1938, 1939, and 1940), as well as the few remaining original adult bluegills. No bass stomachs were taken in March, but, in April, 9 of the total of 15 original stock bass collected (1938 brood) contained fish and 7 contained crayfish, table 10. These two items together made up 54 per cent of the weight of all food taken. Other important items were Diptera larvae, dragonfly nymphs, and miscellaneous insect fragments. As indicated previously, growth of the broods of bass was slow until the plant die-off in August. In August and September, after the rooted plants disappeared, stomach contents of bass of all broods (1938, 1940, and 1941) showed a smaller variety of foods and a higher percentage of fish than in any other 2-month period, and growth was very rapid. It is of some interest to note here that in August and September a few of the small 1941 brood bass ate small leopard frogs and their metamorphosing tadpoles. Although bullfrog tadpoles were always numerous in Fork Lake, they were found rarely in bass stomachs.

In 1941, as in previous years, bluegills fed largely on Diptera larvae, damselfly

nymphs, dragonfly nymphs, *Daphnia*, and snails.

Table 11 represents a summary of food items for all years shown as percentages of the total weights of all foods taken. Any figure of less than 4 per cent has been omitted. This table also lists the average lengths of the broods of bass and bluegills collected at the beginning and end of each collecting season, so that a comparison may be made between length increment and kind of food consumed.

Although Diptera larvae appeared to be very important in the diet of bluegills, as did Entomostraca and snails, no difference in growth of 1938 and 1939 brood bluegills can be shown to be associated with certain foods.

The importance of specific types of food in the diet of bass is obvious. In the 1938 brood bass, the only brood of this species present throughout all years of this study, there seemed to be a direct relationship between rate of growth and the percentage by weight of fish and crayfish in the diet. In 1939, collections of bass indicated that this brood increased 1 inch in length and made a relatively small weight increase; the percentages of fish and crayfish in the diet were 13.8 and 9.2, respectively, table 11. In 1940, the average length of 1938 brood bass in the collections increased from 7 to 10 inches and the weight more than doubled; the percentages of fish and crayfish in the diet were 21.2 and 13.0, respectively. In 1941, in spite of the fact that bass in the collections averaged 10 inches and about 0.5 pound in weight at the beginning of the collecting season, they increased an average of 3 inches in length and nearly tripled their weight in that year; the percentages of fish and crayfish in their diet were 34.5 and 34.4, respectively. In both the 1940 and the 1941 broods of bass, growth was rapid on a diet of fish, small frogs, and tadpoles.

The more common forms of Diptera larvae found in bass and bluegill stomachs were the Chironomidae (midges)—*Chironomus* and *Tanytus*; Chaoboridae—*Chaoborus*; Ceratopogonidae (biting midges)—*Palpomyia*, *Bezzia*, and *Probezzia*; Simuliidae (black flies)—*Simulium*; Stratiomyidae (soldier flies)—*Stratiomys*, *Odontomyia*; and Culicidae (mosquitoes)—*Culex*. No attempt was made to identify families or genera of Mayfly nymphs. The

Table 10.—Results of stomach analyses of bass and bluegills taken from Fork Lake in 1941. In the columns designating types of food, figures not in parentheses represent percentages of total weight of stomach contents; figures in parentheses represent frequencies of occurrence on the basis of 100 stomachs. Analyses of bluegill stomachs were discontinued after May.

MONTH AND GROUP OF FISH	NUMBER OF STOMACHS		TOTAL FOOD, GRAMS	DIPTERA		EPHEMERIDA		TRICHOPTERA LARVAE	DAMSELFLIES	
	Empty	With Food		Larvae	Adults	Nymphs	Adults		Nymphs	Adults
<i>March</i>										
1938 Bluegills.....	1	7	4.557	76.8 (86)	—	—	—	—	9.5 (29)	—
1939 Bluegills.....	1	38	14.520	60.2 (89)	—	tr. (3)	—	—	3.1 (24)	—
<i>April</i>										
1938 Bass.....	2	15	18.206	11.4 (47)	—	2.1 (20)	—	—	0.8 (13)	—
1938 Bluegills.....	0	3	2.200	62.7 (100)	—	0.9 (33)	—	—	—	—
1939 Bluegills.....	5	21	7.093	24.0 (43)	—	—	—	—	15.7 (19)	—
<i>May</i>										
1938 Bass.....	3	19	20.493	1.2 (11)	—	tr. (5)	—	—	9.4 (16)	4.9 (11)
1938 Bluegills.....	1	2	0.071	4.2 (50)	—	—	—	—	—	—
1939 Bluegills.....	0	37	20.692	43.4 (54)	tr. (3)	—	—	0.8 (8)	0.6 (19)	tr. (5)
<i>June</i>										
1938 Bass.....	1	2	2.000	—	—	—	—	—	2.5 (50)	—
1940 Bass.....	0	1	1.200	—	—	—	—	—	—	—
<i>July</i>										
1940 Bass.....	1	4	1.835	1.3 (50)	—	—	—	—	0.5 (25)	—
1941 Bass.....	0	2	0.370	—	—	—	—	—	4.5 (50)	—
<i>August</i>										
1938 Bass.....	0	2	1.566	—	—	—	—	—	—	—
1940 Bass.....	3	6	6.500	—	—	—	—	—	—	—
1941 Bass.....	4	18	6.361	—	—	—	—	—	—	—
<i>September</i>										
1938 Bass.....	2	3	7.000	—	—	—	—	—	—	—
1940 Bass.....	0	3	4.250	—	—	—	—	—	—	—
1941 Bass.....	12	39	22.459	—	—	—	—	—	2.6 (3)	—
<i>October</i>										
1941 Bass.....	2	4	0.068	2.0 (25)	—	—	—	—	—	—
<i>November</i>										
1941 Bass.....	2	3	1.850	—	—	—	—	—	—	—

Table 10 (continued)

MONTH AND GROUP OF FISH	DRAGONFLIES		WATER BOATMEN	WATER STRIDERS	AQUATIC BEETLES		TERRESTRIAL INSECTS AND WORMS	INSECT FRAGMENTS	FISH	CRAWFISH
	Nymphs	Adults			Larvae	Adults				
<i>March</i>										
1938 Bluegills.....			0.6 (14)							
1939 Bluegills	1 2 (8)		1.4 (13)	0 2 (3)	tr. (5)	tr. (3)	0.7 (3)	9.5 (39)		
<i>April</i>										
1938 Bass.....										
1938 Bluegills	9 7 (20)		5.7 (27)		5.9 (7)			16.3 (53)	28.5 (60)	25.5 (47)
1939 Bluegills	0 9 (33)							6.4 (10)		
<i>May</i>										
1938 Bass				1 8 (11)		5.3 (5)	tr. (5)	5 9 (37)	25 9 (37)	17.0 (26)
1938 Bluegills	12.4 (21)				39.4 (100)			9 9 (50)		
1939 Bluegills	0.4 (8)		tr. (5)		20.8 (76)		0.6 (22)	11 9 (41)		
<i>June</i>										
1938 Bass									70.0 (100)	
1940 Bass	10.0 (50)								100.0 (100)	
<i>July</i>										
1940 Bass										
1941 Bass					tr. (25)		0.5 (25)	25.0 (25)	25.0 (25)	
<i>August</i>										
1938 Bass										
1940 Bass								50.0 (100)	50.0 (50)	
1941 Bass								13.9 (17)	83.3 (83)	
									56.1 (61)	
<i>September</i>										
1938 Bass										
1940 Bass									100.0 (100)	
1941 Bass								26.7 (28)	100.0 (100)	
									57.9 (62)	
<i>October</i>										
1941 Bass.....						25.0 (25)		25.0 (25)		
<i>November</i>										
1941 Bass...							25 0 (33)	8.3 (33)	65.0 (66)	

houses of caddis worms were largely those of *Oecetis inconspicua* (Walker), *Molanna*, *Oxyethira*, and *Orthotrichia*. The damselflies were largely of the genus *Enallagma*. Dragonfly nymphs were *Epicorulia* and others; aquatic Hemiptera were *Corixa* and *Notonecta*. Water striders were *Gerris*. The beetle larvae were Dytiscidae (*Dytiscus*), Hydrophilidae (*Enochrus* and *Berosus*), and Haliplidae (*Haliplus* and *Peltodytes*). Terrestrial invertebrates were ants, moths, a wasp, terrestrial beetles, leafhoppers, ichneumonid wasps, March flies, bees, chalcid wasps, house flies, June beetles, grasshoppers, earthworms, and spiders.

Fish were, of course, largemouth bass and bluegills; crayfish were *Cambarus virilis* and *C. propinquus*.

Entomostraca were *Daphnia* and *Ceriodaphnia*, *Cyclops* and *Diaptomus*, as well as *Cypris*. Mollusks were both *Physa* and planorbis type snails and *Musculium*. Coarse plants were *Potamogeton foliosus* and *Anacharis canadensis* (Michaux).

Water mites were not identifiable. Items of infrequent occurrence included leopard frogs, *Rana pipiens* Schreber, and tadpoles of both leopard frogs and bullfrogs, *R. catesbeiana*, hairworms (*Gordius*), seeds, a millepede, slugs, stoneflies, and grass.

Discussion

The investigation of Fork Lake was originally planned to study the effect of heavy cropping upon the combination of largemouth bass and bluegills in a small artificial lake or pond. The results obtained were influenced by the unexpected spread of *Potamogeton foliosus* in this pond, and a proposed final fish census was rendered impossible by a washout of the dam in 1942.

In 1938, at the time the pond was cleared of its old fish population and restocked with a known number of bass and bluegills, little careful experimental work had been done on fish stocking. The number of largemouth bass fry (1,440) placed in the pond proved to be too large; after making rapid growth in 1938, these fish practically stopped growing until their numbers had been considerably reduced by fishing. At the time of stocking it was believed that cannibalism among the

young bass and predation by the adult bluegills would result in the survival of fewer of these fish.

The decision on the number of bluegills to stock was based on the assumption that the adult bluegills would spawn in 1938 and furnish bluegill fry and fingerlings for bass food. It was believed that the adults themselves would add enough flesh in that season to give a harvestable crop of about 100 pounds of large bluegills in 1939, and yet leave adequate available food for rapid growth in the surviving bluegill spawn. Therefore, it was decided that a stocking of 200 to 250 sexually mature bluegills should be adequate, and 240 were stocked.

The number of bluegills stocked was more nearly correct for Fork Lake than was the number of bass. The original bluegill stock increased in weight to 0.35 or 0.40 pound each by 1939 and produced a large spawn, a part of which survived and grew rapidly to good sizes. These 1938 brood bluegills furnished most of the bluegill yield during 1939 and 1940.

Since 1938, Smith & Swingle (1943) have furnished valuable information on the survival of bass and bluegill fry stocked in new ponds in the South. The intensive cropping of Fork Lake with small-mesh wing nets did not deplete the bass or seriously reduce the number of bluegills, in spite of the fact that these nets caught 5.0-inch bass and 3.5-inch bluegills and that practically all fish trapped in nets were removed from the pond. Some growth compensation must have resulted from cropping during 1939 in the 1938 brood bluegills, and during 1939 and 1940 in the 1938 brood bass. These bass probably would have remained at about 6 to 8 inches had their numbers not been reduced. The fact that this small pond contained at least 66 bass of the 1938 brood after 3½ years of intensive net fishing suggests that this type of gear is inefficient in catching this species, or perhaps that bass learn by observation to avoid wing nets. The total yield of bass would have been much lower had no attempt been made to crop them by angling. Sportsmen often assume that the nets of commercial fishermen are to blame for an apparent scarcity of bass. The Fork Lake experiment seems to indicate that this assumption is unfounded.

Table 11.—Percentages of total weight of all food items in the stomachs of bass and bluegills taken each year from Fork Lake, 1939, 1940, 1941. Percentages of less than 4.0 have been omitted.

YEAR AND GROUP OF FISH	AVERAGE LENGTH, INCHES		DIPTERA LARVAE	DAMSELFLIES		DRAGONFLIES		WATER BOATMEN
	Beginning	End		Nymphs	Adults	Nymphs	Adults	
1939								
1938 Bass.....	6.0	7.0	9.9	—	10.2	4.6	4.0	21.3
Original bluegills.....	7.5	7.7	33.9	—	—	—	—	8.3
1938 Bluegills.....	3.5	6.5	31.2	—	—	—	—	—
1940								
1938 Bass.....	7.0	10.0	34.0	—	—	19.8	—	—
1938 Bluegills.....	6.5	7.4	38.8	—	—	—	—	—
1939 Bluegills.....	4.7 ¹	4.8	35.5	6.3	—	—	—	—
1940 Bass ²	—	4.0	—	4.4	—	—	—	—
1941								
1938 Bass.....	10.0	13.0	—	—	—	11.9	—	—
1938 Bluegills ³	7.6	7.8	71.7	6.3	—	—	—	—
1939 Bluegills ³	4.8	6.3	45.9	—	4.0	—	—	—
1940 Bass.....	4.0	10.5	—	—	—	—	—	—
1941 Bass ²	—	6.5	—	—	—	—	—	—

¹ June.

² Fall only.

³ Spring months only.

Table 11 (concluded)

YEAR AND GROUP OF FISH	AQUATIC BEETLES		INSECT FRAGMENTS	FISH	CRAYFISH	CLADOCERA	SNAILS	COARSE AQUATIC PLANTS	ALGAL	MISCELLANEOUS
	Larvae	Adults								
1930										
1938 Bass.....	—	—	12.3	13.8	9.2	—	—	—	—	—
Original bluegills.....	—	—	—	—	—	8.4	11.5	6.8	8.8	—
1938 Bluegills.....	—	—	7.1	—	—	29.7	9.2	—	—	—
1939 Bluegills.....	—	—	—	—	—	—	—	—	—	—
1940 Bass.....	—	—	—	21.2	13.0	—	—	—	—	—
1938 Bass.....	—	—	21.5	—	—	28.5	4.5	—	—	—
1938 Bluegills.....	—	—	14.4	—	—	15.4	5.8	—	5.0	—
1939 Bluegills.....	—	—	—	95.2	—	—	—	—	—	—
1940 Bass.....	—	—	—	—	—	—	—	—	—	—
1941 Bass.....	—	—	—	—	—	—	—	—	—	—
1938 Bass.....	—	4 1	4.0	34.5	34 4	—	—	—	—	—
1938 Bluegills.....	—	—	—	—	—	8.7	9.9	—	—	—
1939 Bluegills.....	10.2	—	10.2	—	—	16.5	5.4	—	4.0	14.7 ²
1940 Bass.....	—	—	—	79.1	—	—	—	—	—	17.1 ³
1941 Bass.....	—	—	5.5	75.3	—	—	—	—	—	—

1 Fall only.
2 Spring months only.
3 Frogs and tadpoles.

The yield of fish decreased during the period of cropping. Theoretically, as fish are continually being removed from a body of water, and the fertility of the water is maintained at a nearly constant level, those fish that remain will have more available food per individual, and, because fish growth follows no definite pattern correlated with age, this increase in food for each individual fish will allow rapid growth to continue throughout the life span of each individual, or until it in turn is captured and removed. In spite of heavy cropping of bluegills, growth rate of the bluegills escaping the nets did not improve; in fact, the growth rate of this species decreased with each successive year. The decrease can be explained, in my opinion, only on the basis that the total food supply of the omnivorous bluegills in Fork Lake was reduced so rapidly from year to year by the spread of potamogeton that constant cropping did not increase the per capita food supply.

The pond was thermally stratified throughout each summer with only a trace of oxygen below 4 feet (Bennett, Thompson, & Parr 1940) so that throughout much of the fish growing season only bottom forms such as *Chaoborus* were found in the deeper open waters of the pond. Such bottom organisms as were able to live among the roots of the aquatic plants may have been largely unavailable to larger fishes when the plant growths were rank. Very small fish were nearly always visible within the protective borders of the plant growths. These fish were relatively safe from the larger fishes that would use them for food, but their poor growth rate indicated that their food supply within the plant mats was limited. It may be assumed that the dissolved oxygen in the water among the rank plant growths fluctuated from supersaturation in the day time, when the plants were able to carry on photosynthesis, to absence of oxygen or very low oxygen tension in the period preceding dawn. If the assumption is true, the small fishes may have moved out to the edges of the vegetation, but zooplankton that required oxygen and had only weak powers of locomotion may have suffocated within the plant mats. Thus, the dense mats of vegetation may have acted as traps to many forms of the Entomostraca and caused reduction of these forms in the

pond. Cladocera made up a large percentage of the stomach contents of bluegills in spring and fall, before the rooted vegetation had become dense and after it had died down. Maximum numbers of Entomostraca in large deep lakes are found usually in spring and fall, but according to Pennak (1946), the peak numbers of Entomostraca do not occur with any regularity in smaller lakes and ponds.

It must be considered that the rooted plants were competing with algae for the dissolved plant nutrients in the water. These nutrients were bound up within the bodies of the rooted plants during much of the growing season of fish and, as these plants were not a source of food for fish or many of the fish food organisms, they may have reduced the carrying capacity of the pond for fish.

The removal of a large poundage of fish from Fork Lake each year might be expected to reduce the productivity of the pond, if the water entering from the drainage basin were relatively sterile. However, the watershed of Fork Lake is good corn land, pasture, and timber.

The above are hypotheses that may explain in part the reduced yield of fish from Fork Lake and the absence of growth compensation in bluegills, despite heavy cropping.

The study of foods ingested by large-mouth bass, table 11, demonstrates that fish and crayfish are essential for rapid growth in this important fish species.

During the die-off of vegetation and the "bloom" period in 1941, the bass made excellent growth because the vegetation-inhabiting small fish suddenly were made available for food at a time when the water was warm enough for rapid assimilation and growth. It must be assumed, because of lack of a similar increase in growth rate of bluegills, that the death of the plants released no comparable supply of food for bluegills, and that no large source of invertebrate food developed as a result of the algal "bloom." Failure of the invertebrate population of Fork Lake to expand as a result of the algal "bloom" may have been due to the specific kind of algae that developed, or it may have been that the season or physical conditions in the pond were not right for an eruption of Entomostraca or a sizable increase of insect larvae.

Summary

1. The fish in Fork Lake, a pond of 1.38 acres near Mount Zion, Illinois, were poisoned and the pond restocked with 1,440 largemouth bass fry and 240 adult bluegills in June, 1938.

2. Beginning in March, 1939, the fish were cropped with 1-inch-mesh wing nets and with hook and line; nets were fished, March through November, in 1939, 1940, 1941, and, March through June, in 1942; with few exceptions, fish caught were removed from the pond. The yield was 223.0 pounds in 1939, 200.0 pounds in 1940, 130.0 pounds in 1941, and 60.5 pounds in 1942 (4 months). During the years in which cropping continued through November, the bass yield remained at about 50 to 60 pounds.

3. On July 8, 1942, the dam was washed out by a 4-inch rain. The part of the fish population trapped in a net across the break and in the pond basin amounted to 169 pounds of bass and 92 pounds of bluegills or a total of 261 pounds. Sixty-six of the original bass stocked in the pond as fry in 1938 were taken in the washout.

4. The most noticeable change in the pond habitat during the years of cropping was an increase in the abundance of fine-leaved pondweed, *Potamogeton foliosus*. In 1939, plants of this species reduced the area of open water to 1.25 acres, in 1940 to 0.95 acre, and in 1941 to 0.64 acre. The progressive annual decrease in fish yield seemed to show a positive relationship to the progressive decrease in the area of open water.

5. Bass growth was slow in 1939 and in the March-June period of 1940 and 1941, fig. 6. Some improvement occurred in the July-October period of 1940 after both bass and bluegill young were available for food. In August, 1941, a sudden die-off of *Potamogeton foliosus* occurred and was followed by a "bloom" of algae, *Aphanizomenon flos-aquae*. With the disappearance of the protective mats of potamogeton, the small fish became available for food, and the bass began to grow at a very rapid rate. Despite intensive cropping, each successive brood of bluegills spawned in the pond grew less rapidly than the preceding brood; bluegills showed no improvement in growth rate as a result of the plant die-off of August, 1941.

6. Improvement in condition (relative plumpness) of bass paralleled periods of rapid growth; in bluegills a regular yearly cycle of condition was shown by all broods, with a high condition in spring and a low in November. No improvement in condition of bluegills followed the plant die-off of 1941.

7. Scales of the 1938 broods of both bass and bluegills showed abnormalities such as false annuli, skipped annuli, and close spacing of annuli; nearly all of these abnormalities appeared during the growing season of 1939. Scales of later broods presented almost no false rings or unusual spacing of annuli. It is believed that the abnormalities of 1939 were associated with very rapid growth in the bluegills and with very slow growth in the bass.

8. Broods of young bluegills were produced in the pond each year. The bass fry stocked in 1938 first became sexually mature in 1940 and large broods of bass were produced in that year and the years following.

9. A histological study of the sexual cycle of bass and bluegills made by Dr. Marian F. James (1946) indicated a short spawning season for bass (May) and a longer season for bluegills (May through September). Bluegills became sexually mature at an age of 12 months unless badly stunted; although several of the larger male bass produced a few sperms at 1 year, no females produced mature eggs until 2 years of age.

10. Stomach analyses of Fork Lake bass and bluegills indicated that, when fish and crayfish were scarce, bass competed with the bluegills for insects and Entomostraca and made poor growth. The rate of growth in bass was apparently correlated with the percentages of fish and crayfish in the diet. Bluegills of all sizes fed largely on Diptera larvae, Entomostraca, and snails; no correlation was found between growth rate and the ingestion of certain kinds of food in bluegills.

11. Bluegills in Fork Lake grew at a decreasing rate throughout the years of cropping, and the yearly yield in pounds of these fish was progressively smaller each year. Together, these phenomena indicate a diminishing supply of food in the pond for these fish. If the food supply had remained constant in total volume from year to year, the removal each year of a large

crop of bluegills from 3.5 to 9.0 inches in length would have increased the food supply for those fish remaining and resulted in an accelerated growth rate. The mats of aquatic vegetation probably greatly reduced the production of invertebrate fish foods in the pond shallows and thereby more than nullified the effect of cropping.

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Recent Publications

A.—ILLINOIS NATURAL HISTORY SURVEY BULLETIN.

- Volume 22, Article 1.—The Plant Bugs, or Miridae, of Illinois. By Harry H. Knight. September, 1941. 234 pp., frontis. + 181 figs., bibliog., index. \$1.25.
- Volume 22, Article 2.—Studies of North American Plecoptera, with special reference to the fauna of Illinois. By T. H. Frison. September, 1942. 122 pp., frontis. + 126 figs., bibliog., index. \$1.00.
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BULLETIN

of the

ILLINOIS NATURAL HISTORY SURVEY

HARLOW B. MILLS, *Chief*

The Pseudoscorpion of Illinois

C. CLAYTON HOFF

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Volume 24

BULLETIN

Article 4

The Pseudoscorpions of Illinois

C. CLAYTON HOFF



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URBANA, ILLINOIS

June 1949

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This paper is a contribution from the Section of Faunistic Surveys and Insect Identification.

FOREWORD

During the latter part of 1946, all the zoological collections of the Illinois Natural History Survey were brought together into one section, formerly the *Insect Survey Section*, which was then renamed the *Section of Faunistic Surveys and Insect Identification*. Previously, the Natural History Survey had published a series of reports on the insects of Illinois and, at the same time, had developed the entomological collections. The double aim of the above reorganization was, first, to effect a well-balanced program in the Survey's faunistic activities with the hope that useful reports on the Illinois fauna would be made for groups other than insects and, second, to build up a comprehensive reference collection of study material for the identification of animal groups occurring in the state.

A firm basis of expansion in several non-insect groups, such as the fish and mollusks, was provided several years ago by the extensive Illinois collections of Stephen A. Forbes, Robert E. Richardson, and Frank C. Baker. Although in recent years certain other groups, especially the arthropods and reptiles, have been fairly well collected in the state along with the insects, our collections of many forms are at a beginning level.

The general aim for all groups is now the one that has been developed for the insects: to build up as extensive and inclusive a collection of Illinois species as possible, and to supplement this with representatives of other North American genera and species in each group.

We feel fortunate in presenting this account of the pseudoscorpions of Illinois as the first report of the expanded part of the program. In 1943 we began a co-operative undertaking with Dr. C. Clayton Hoff, then at Quincy College, Quincy, Illinois, with the view of investigating the pseudoscorpion fauna of the state. At that time we were making extensive ground cover samples in connection with certain insect projects, and this activity dovetailed very well with a sur-

vey of the pseudoscorpions. Dr. Hoff reported such unusual findings, and a fauna so much more extensive than had been expected, that we soon decided to make his study the basis of a thoroughgoing faunistic report on the group for Illinois.

This decision was strengthened by the very apparent need for such a study of the pseudoscorpions. Up to about 1930 the taxonomy of this group in North America was in a preliminary and superficial stage. It was not until comprehensive analyses of the known world fauna were presented by J. C. Chamberlin and Max Beier in the 1930's that a groundwork was laid for modern studies of the group. Since no detailed faunistic report has previously been prepared for any region on the North American continent, we hope that this Illinois report will prove useful to many investigators.

We are grateful indeed to Dr. Hoff for the identification of material and preparation of the manuscript, and for contributing much of his own time to this project. Members of our staff in the Section of Faunistic Surveys and Insect Identification have contributed materially to the project. Several of them have assisted with the field program and with adaptation of the manuscript to current Survey practices. Four total views of pseudoscorpions were prepared especially for this work by Dr. Carl O. Mohr, formerly Associate Entomologist and Artist. Mr. James W. Curfman assisted with the preparation, numbering, and lettering of the plates. Mr. Lewis J. Stannard, Jr., Mrs. Leonora K. Gloyd, and Mrs. Dorothy A. Moulton compiled the index and assisted in assembling the Illinois records, preparing the bibliography, and checking and integrating the manuscript.

We have enjoyed throughout the help and co-operation of the Technical Editor, Mr. James S. Ayars, and Mrs. Drew S. Wetzel and Mrs. Blanche P. Young of his staff.

HERBERT H. ROSS
Systematic Entomologist

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Ground cover or duff in woods such as these harbors a wide variety of pseudoscorpion species. When a sample is to be collected, the dry top leaves should be brushed away and the moist lower leaves and the top layer of soil scooped up. Samples from the lee of a log are often unusually productive.

The Pseudoscorpions of Illinois

C. CLAYTON HOFF*

PSEUDOSCORPIONS are minute animals only a few millimeters long, with the general appearance of diminutive scorpions except that they have no tails. They belong to the large phylum of joint-legged animals, the Arthropoda, and to the class Arachnida, which, in addition to the pseudoscorpions, embraces the spiders, mites, ticks, scorpions, and other related groups. Pseudoscorpions are seclusive in habit, occurring in soil cover and rotten logs, under bark, and in similar places out of doors; one species is found in houses. In their natural habitat, these little brown animals are difficult to see, especially when they draw in their legs and "play possum." In this position they look like little specks of dirt. Probably because pseudoscorpions are inconspicuous, few collections of the group have been made in the past, and the fauna, at least of North America, and especially of the central and north-central United States, has remained scantily known. Prior to the initiation of the present studies, only one list was available for this region, that of Ewing (1911), which contained records of six species from Illinois and two additional species from neighboring states.

Two factors have contributed to a considerable expansion of our knowledge of this group for the Illinois region. The first factor was the work of J. C. Chamberlin and Max Beier, both of whom, about 1930, made extensive contributions to the taxonomy of the world fauna of the pseudoscorpions, delineating the suborders, families, and genera clearly for the first time, and utilizing an abundance of new identification characters. The second factor was the development of the Berlese funnel method of collecting pseudoscorpions and associated small animals. This method, described on page 418, has made possible collecting of

large series of many species and obtaining for the first time what appears to be a fairly accurate representation of the total fauna of Illinois. At the present time the list of known Illinois species stands at 26. Undoubtedly, other species will be found with additional collecting; the present study, based on over 5,000 specimens, represents about 350 collections.

The object of this report is twofold, first to present illustrated keys and descriptions for the identification of species in this region, and, secondly, to summarize information regarding the distribution, biology, and habitat preferences of the species. As an aid in use of the keys, a section has been included on morphology, in which the structures now considered of major taxonomic importance are explained.

Summarizing the distribution has been especially difficult because many identifications made prior to Chamberlin's work are probably incorrect and should be rechecked before they are cited. Because of this situation there is little accurate information to serve as a guide in foretelling what additional described species may be collected in Illinois. In order to make this report of wide application, the keys have been made to include all the genera known from the central and northeastern portions of the United States and adjacent portions of Canada.

BIOLOGY

Available information on the development and habits of pseudoscorpions is meager and is based chiefly on the study of a few large species, most of them of the suborder Monosphyronida. Scarcely any biological information is available for the smaller forms belonging to the suborders Diplosphyronida and Heterosphyronida.

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Feeding Habits

Pseudoscorpions feed on small animals such as mites, ants, and a wide variety of other insects, as indicated by the many pseudoscorpions observed with such prey in the chelae of the pedipalpi or palps. The pseudoscorpion's mouth, located on a tubular structure called the rostrum, contains a sucking structure, the pharyngeal pump, for taking in liquid food. The pseudoscorpion grasps its prey with the palps. These prehensile organs are supplied with a venom apparatus that effectively kills or anesthetizes the captured prey within a matter of seconds. The palps and chelicerae, together or singly, hold the prey to the mouth and the pseudoscorpion sucks the fluids from the body of its victim.

The larger pseudoscorpions, especially *Chelifer cancroides*, make interesting pets. One may be kept in a small corked vial into which is released a fly occasionally. The pseudoscorpion will stalk the fly patiently for a long time; then suddenly it will reach out a palp and seize the fly. A good-sized house fly will put up quite a struggle, sometimes flying around with the pseudoscorpion attached; sometimes the pseudoscorpion will be stretched out in mid-air, grasping the cork with one chela and the fly with the other; but in a few moments the battle is over, and the fly is completely quiet. Then the feast begins.

Evidence to date indicates that no pseudoscorpions live as ectoparasites on larger animals. Pseudoscorpions occur abundantly in mammal and bird nests, but apparently they are not parasitic on the mammals or birds but instead feed on small arthropods in the nests. Species have been reported as nipping man, but without inflicting any appreciable injury (Beier 1932*d*, 1941; Feio 1941).

Large numbers of species have been reported from beneath the wings or elytra of beetles, as well as from the bodies of other insects and birds, as described by Vachon (1940, 1947). These cases appear to be nothing more than phoresy, with the pseudoscorpions feeding on mites and other soft-bodied arthropods associated with the larger flying insects and birds. Vachon forcefully expresses the idea that phoresy with few exceptions is confined to the females. He believes that phoresy is a response to insufficient food at a time when the females are carrying and feeding the larval young.

Enemies

While pseudoscorpions prey upon smaller animals, they are in turn the prey of larger animals, especially birds, as indicated by the frequency with which pseudoscorpion remains are recovered from the digestive tract of birds. The part played in food cycles appears to be the pseudoscorpions' claim to ecological importance.

Development

Pseudoscorpions have several distinct stages in their life history: (1) the egg, in most species carried by the female; (2) the larva, in most species also carried by the female; (3) three stages of nymphs, which are free living; and (4) the adult.

The pseudoscorpion female usually produces only a small number of eggs, ranging from 3 or 4 to as many as 30. The eggs in most species are not laid indiscriminately, but are simply extruded from the abdomen and retained as a group attached to the base of the abdomen in contact with the external genitalia. As the eggs are laid, they are grouped in a single-layered rosette or around the periphery of a spherical mass. In either case the egg mass becomes enclosed by a thin membrane.

As young develop within the eggs, the enveloping membrane is lost and the larvae assume positions with their heads toward the center of the rosette or spherical mass. Each of the first stage larvae has a sucking apparatus for feeding, and rudiments of the appendages, nerve ganglia, and other structures. The larvae secure a nutrient fluid secreted from the maternal ovaries, which become modified for this particular function. During the period of larval development the females of those groups in which the larvae form a single-layered rosette remain active, while the females in which the larvae are arranged in the form of a spherical mass have been observed to seal themselves in a nest and remain inactive. The presence of large amounts of yolk in the eggs of a few species (Essig 1929) suggests that the larvae in these groups develop without attachment to the mother.

As development continues, a second larva stage is formed. In this stage, the sucking apparatus is atrophied and the larva apparently lives on the food accumulated during the first or feeding stage of larval development. Also, during the second larva stage, the appendages and other structure

of the nymph gradually make their appearance.

At the end of the larval development, the first nymphal stage or protonymph escapes from the brood pouch and begins to lead an independent life. The protonymph has essentially the same general appearance as the adult. The continued development includes three molts, and the individual passes successively through the *protonymph*, *deutonymph*, and *tritonymph* stages, to form finally the sexually mature adult stage. At the time of each molt, the nymph secludes itself in a silken nest for a period of 10 or 15 days, during which time distinct morphological reorganizations take place. The various morphological changes that occur between nymphal stages and between the tritonymph and the adult include the gradual addition of tactile setae on the palpal chelae and a gradual change in the shape of various body parts, such as the segments or podomeres of the appendages. The nymphal stages of one Illinois pseudoscorpion, *Apochthonius moestus*, have been discussed in detail by Hoff (1946b); the various stages of another species, *Chthonius tetrachelatus*, have been described by Vachon (1941a, 1941b).

Maturity and Reproduction

Adult pseudoscorpions are undoubtedly fairly long lived, living probably for 6 months to a year or two. This surmise is based on collecting observations and notes made on a few individuals kept in captivity. Few exact data over an extended period are available.

As is true of their relatives, pseudoscorpions are dioecious. The males and females are similar in appearance. With the possible exception of a few forms, such as the genus *Microbisium*, in which the males have never been found, they reproduce sexually; apparently in the *Microbisium* females reproduce parthenogenetically.

According to Beier (1932d), mating takes place in the spring, during April and May, but this information is based on the study of only a few forms in the holarctic region and possibly cannot be applied to species from other areas. Unfortunately, information relative to mating is from observations of a few species of Monosphyronida only, and generalizations cannot be made for the entire order. In the few species that have received detailed study (Kew 1912), the male and female perform a courtship dance as a part

of the mating activity. During the period of marked sexual activity and the courtship dance, a spermatophore is released by the male. Sperms from this spermatophore are picked up by the female. About 1 month after the transfer of sperms from the male to the female, the eggs are extruded.

HABITAT PREFERENCES

Pseudoscorpions have invaded many different habitats in almost every part of the world. For the most part, the smaller forms live in debris and fertile soil, the larger forms under stones, under bark of trees, in decaying vegetation, and abundantly in mammal and bird nests. One genus, *Garypus*, is found usually along the seacoast under stones and among algae and seaweeds.

Some species of pseudoscorpions occupy very particular and restricted niches. The habitat relationships of most Illinois pseudoscorpions are summarized below. A few species are omitted as a result of inadequate ecological data.

Deciduous Forests

The abundant microhabitats found in the forest, fig. 1, afford the favorite living conditions for pseudoscorpions in Illinois. The species inhabiting forest ground cover and decaying wood are among the most abundant and widely distributed of our pseudoscorpions.

Three species have been found only in ground cover and litter: *Apochthonius moestus*, *Heterochthonius multispinosus*, and *Mundochthonius sandersoni*. *Dactylochelifer copiosus* has been found in the same habitats, and one collection of this species was swept from vegetation.

Five species have been found chiefly in rotting wood or under bark of logs and stumps: *Verrucaditha spinosa*, *Lamprochernes oblongus*, *Dinocheirus pallidus*, *Pseudolamprochernes parvus*, and *Acuminochernes crassopalpus*. The last two are especially common in the rotten wood and debris of hollow trees.

Two species, *Parachernes squarrosus* and *Microbisium confusum*, are found both in ground cover and in rotting logs and stumps; *Mirochernes dentatus* occurs in both habitats and also is common in cavities of hollow trees.

Under bark of living trees, chiefly oak and hickory, occurs *Idiochelifer nigripalpus*.



Fig. 1.—Woods at Starved Rock State Park, Illinois. Wooded hillsides offer a wide variety of habitat niches: ground cover, rotten logs, hollow trees, moss, and root tangles. All these are prospective pseudoscorpion habitats.

Rock Outcrops

Three species have been found associated with rock outcrops, fig. 2. These pseudoscorpions live in the debris and leaf mold on the rock ledges or at the bases of outcrops. *Chthonius tetrachelatus* has been taken in association with limestone outcroppings; *Mundochthonius rossi* and *Larca granulata* have been taken only around sandstone outcroppings.

Sand Dunes

Our only collections of *Paisochelifer callus* have been taken in grass and ground cover in sand dunes.

Swamps and Bogs

Microbisium brunneum has been taken in Illinois only in the moss and debris in tama-

rack bogs of the northern part of the state and in cypress swamps of the southern tip.

Domestic Situations

Chelifer cancroides is never found in natural habitats removed from habitations of human beings. Around man, however, it is widespread and abundant, occurring in chicken houses, barns, dwellings, beehives, and nests of starlings and sparrows.

DISTRIBUTION

Pseudoscorpions are found in all parts of the world except in the arctic and the antarctic regions. They reach their greatest degree of development both in population numbers and in diversity of species in the tropics and subtropics. Many of the super-

families or families are world-wide or nearly world-wide in distribution, with at least a few representatives on nearly every large land mass and with a concentration of closely related species on one or two of the continents. Thus, the diplosphyronid superfamily Neobisiidea is holarctic, while the heterosphyronid Tridenchthoniidae and monosphyronid Atemnidae are typically circumtropical. In the Tridenchthoniidae, however, we

find a few species in the nearctic region and in the Atemnidae a few species outside of the distinctly tropical regions. Most of the family and subfamily groups have representatives in a wide geographical area.

Such a widespread distribution appears interesting in a group without apparent means of rapid dispersal. There are several possible ways, however, by which dispersal may be accomplished. The small forms are

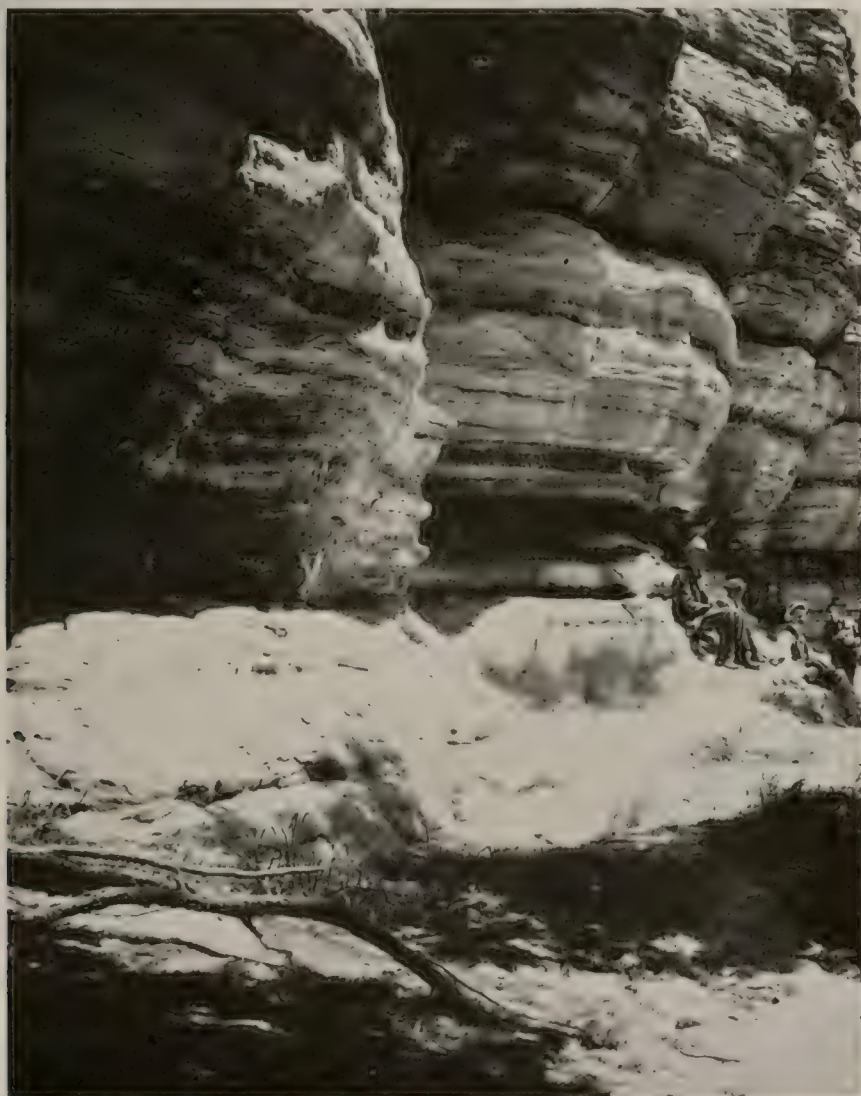


Fig. 2.—Sandstone ledges in Starved Rock State Park, Illinois. Dry leaves and sparse grass accumulate on the ledges and in the crevices of these outcrops to form a thin, dry layer of organic material. A few animals, apparently especially adapted to these dry conditions, live here. One of the denizens of these ledges is the Illinois pseudoscorpion *Mundochthonius rossi*.

readily carried by air currents and even the larger species may on occasion be carried in this way just as are many of the insects and spiders. Many forms are no doubt transported by large insects and by mammals and birds. Man may be an important factor in distribution of some species, as indicated by the widespread domestic distribution of *Chelifer cancroides*, and by the many specimens of other pseudoscorpions taken from merchandise at quarantine stations along the seacoast (Chamberlin 1938). Whether any of these latter man-introduced species have ever become established in a new area is not at present known.

As with other animal groups, the Illinois pseudoscorpion fauna contains some species that are widely distributed and even cosmopolitan, and others that are greatly restricted in their geographical ranges. It has seemed worth while to group most of the species taken in the state according to area of distribution. The remainder are recorded from only one or two counties and the data relative to distribution are possibly incomplete. It is possible that the rarity of some species is more apparent than real, and that the apparent rarity results from greatly restricted habitat niches or from an insufficient number of collections. Additional information relative to the distribution records of the various species may be found in the systematic section of this paper.

Widely Distributed Species

Ten species have been collected from a sufficient number of Illinois localities to indicate that they are widely distributed over the entire state. These include some of our very common forms: *Apochthonius moestus*, *Microbisium confusum*, *Lamprochernes oblongus*, *Parachernes squarrosus*, *Pselaphochernes parvus*, *Acuminochernes crassopalpus*, *Mirochernes dentatus*, *Chelifer cancroides*, *Idiochelifer nigripalpus*, and *Dactylochelifer copiosus*.

Microbisium brunneum, associated with bogs or swamps, has been taken at the northern and southern extremities of the state but not in areas between. Among the species infrequently collected, *Chthonius tetrachelatus* and *Illinichernes distinctus* have been taken from northern and southern localities.

Southern Species

Two species, *Heterochthonius multispinosus* and *Mundochthonius sandersoni*, have

been taken from only the southern tip of the state. *Verrucaditha spinosa* has been found only in the Mississippi River drainage area in the south-central and southern parts of the state.

Northern Species

To date *Mundochthonius rossi* has been found only in the northern fourth of the state. In the same category are three other species that have been taken occasionally, *Dinocheirus pallidus*, *Dinocheirus solus*, and *Paisochelifer callus*.

Other Species

Six species that have been collected infrequently are known from central or north-central counties in the state, from the vicinity of Urbana, an area from which we have collected a large number of samples, or from widely separated local areas. Similar intensive collecting in other areas may show these species to have a much wider distribution in Illinois. The six species are *Chthonius ischnocheles*, *Lamprochernes minor*, *Reginachernes ewingi*, *Reginachernes lymphatus*, *Larca granulata*, and *Chelanops* (?) *corticis*.

COLLECTING METHODS

Collecting of large pseudoscorpions, especially those belonging to the suborder Monosphyronida, may be done by hand from the bark of trees and logs or by sifting soil, debris, and rotten wood. However, collecting of most pseudoscorpions in these ways is laborious and slow because of the low population density of some species and because of the small size, seclusive habits, and light color of other species, especially those of the suborders Heterosphyronida and Diplosphyronida.

The most efficient method for collecting pseudoscorpions is by the use of Berlese funnels, named after the Italian entomologist Berlese, who first used them extensively. A Berlese funnel is a very simple apparatus, fig. 3, consisting of a fairly long funnel suspended wide end up, with a screen placed about a third of the way down the funnel, with heat applied either around the upper portion of the funnel or over the top of the funnel, and with a container of preservative, preferably 80 per cent ethyl alcohol, around the small bottom opening. Leaf mold, bark scrapings, broken-up rotten

wood, and other material suspected of harboring pseudoscorpions is placed on the screen, the heat source is turned on, and after a day or so the pseudoscorpions leave the dried sample and migrate downward, dropping into the preservative.

half-inch mesh. Clumps of moss, leaves, sod, and pieces of wood or bark are torn up by hand into small fragments as they are put into the sieve; then this material is raked over the sieve and shaken, the sifted material being collected on a cloth or paper, fig. 4.

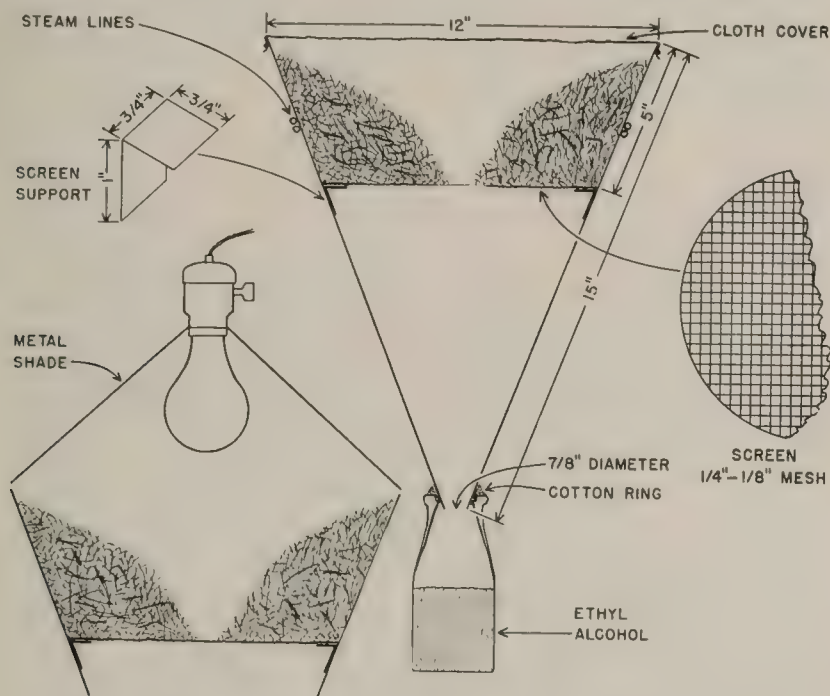


Fig. 3.—Sketch of a Berlese funnel, showing a diagrammatic view across the middle. The central figure shows an arrangement for a steam coil, the lower left for an electric light. The Berlese funnel provides the most efficient method for collecting pseudoscorpions and certain other animals.

Fig. 3 illustrates a funnel that has proved very satisfactory; it is 15 inches from top to bottom and the top has a diameter of 12 inches. The bottom opening, exactly seven-eighths inch in diameter, fits into a half-pint cream bottle, which makes an ideal container for the preservative. Three angled brackets or hangers are soldered inside the funnel to provide a rest for the screen, which is made of a quarter-inch or eighth-inch mesh hardware cloth; the mesh used depends upon the type of sample. A battery of several funnels in a rack will allow the collector to sample a hundred pounds or more of material in one operation.

Samples of leaf mold or other material are brought into the laboratory in cloth bags. Before being put in the funnel, each sample is sifted carefully through a screen sieve of

Pieces of wood or bark are knocked sharply against each other to dislodge any animals that might cling to them. The sifted material is then placed on the screen in the funnel and piled up around the sides to leave a small open space in the center of the screen, fig. 5. This central opening allows the easy migration of animals in the upper part of the sample down into the bottom part of the funnel. The funnel so loaded is then placed in the rack for support, the bottle with preservative is placed under the narrow end, and heat is applied. Funnels in position in rack are shown in fig. 6.

If steam is used as a source of heat, the small copper lines that conduct it act as a partial support for the funnel by encircling it about half way between the screen and the top; a piece of cloth is tied tightly over



Fig. 4.—Sifting Berlese samples. Preparatory to putting material in the funnel, bark and rotten wood are broken up and these and leaf mold sifted through a coarse screen. The siftings are put in the funnel.

the top of the funnel, fig. 3. If an electric light or a choke coil is used for heating, it should be hung directly over the center of the funnel and no cloth tied over the top. With a light or choke coil, it is often well to use a wide reflector that approximates in diameter the diameter of the top of the funnel.

Care must be taken not to heat the sample too rapidly. Otherwise, moisture will condense in the lower part of the funnel and trap many of the animals working their way

toward the bottom, or the heat may kill many of the organisms before they have an opportunity to move out of the sifted material. A little experience furnishes the best gauge of the intensity of heat to be used. An application of heat sufficient to dry the sample in 4 or 5 days is usually satisfactory. As the sample dries, the organisms move out and downward, and finally drop into the bottle of preservative.

The Berlese funnel is extremely useful for collecting many animals in addition to

pseudoscorpions: groups of beetles, particularly Staphylinidae, thrips, Collembola, many groups of parasitic Hymenoptera, ants, millipedes, and centipedes, and a wide range of other minute animals that live in soil, surface cover, logs, or bark.

Samples for the Berlese funnel may be collected at any time of the year. If collected during the warm months, they should be brought to the laboratory and placed in the funnels within a day or two; otherwise considerable loss of population occurs within the samples. If collected during the cold months, they may be kept in cold storage for a week or two with little loss.

The following suggestions may prove helpful in picking up samples. For leaf mold samples, scrape off and discard the dry surface leaves and scoop up the lower, rotted layers of leaves together with an inch or two of the adjacent soil. You may encounter especially good samples where leaves have blown in along the edge of a log (see frontispiece). In such a situation, take some of the log bark with the sample. Collect rotten log samples in large hunks and break them up in the sieve. From either standing stumps or fallen logs in which the wood is still too hard to break up, collect the loose bark, as it is often quite productive. Fre-



Fig. 5.—Material to be sampled is placed on the sieve in the funnel and piled high around the edges; a small opening is left in the center. This arrangement allows an exit to the bottom for pseudoscorpions and other animals that might otherwise be trapped on top of the debris.

quently if you roll a log over, you may find animal runs under it; the debris and earth under and around these runs, together with animal nests, frequently give unusual catches.

Probably the most productive single type of sample is that taken from the interior of a standing hollow tree. At the bottom of the hollow you may find a foot or more of fine, rotten, woody material that you can scoop out by reaching through a break in the base of the tree. A 50- or 60-pound sample of this is almost sure to net many interesting forms. Occasionally you may collect a wet sample, such as sod from a marsh or debris from a stream edge. If you allow it to remain in the sack for a few days it will

usually dry out enough to permit sifting. Allow winter samples to thaw and dry before you sift them.

PREPARATION OF MATERIAL

Most of the characters used in the identification of pseudoscorpions can be seen only in proper orientation of the specimen and under moderate to high magnifications. For this reason it is necessary to prepare pseudoscorpion specimens carefully so that they may be studied under the compound microscope.

The following method has been found very satisfactory. First, remove from the animal the two chelicerae, the two palps,



Fig. 6.—Funnels in position on rack. In this assembly, each funnel rests inside a double ring of copper tubing (as on funnel at extreme lower left) through which flows live steam. The steam produces the heat that dries out the sample and drives the animals out of it. Cotton or a small rag is tamped between the end of the funnel and the bottle of preservative to prevent escape of specimens.

one of the first, and one of the fourth legs. Leave these in alcohol while the rest of the body is being treated. Next, puncture the body by making a slitlike cut in the side of the abdomen; then place it in a 10 per cent solution of potassium hydroxide. This step is intended to dissolve the muscles and internal organs. Soak the body in cold hydroxide solution for several hours, or in hot solution (heated in a boiling water bath) for a few minutes. The exact amount of time will depend upon the size and darkness of the specimen and can be gauged after a little experience. The object is to clear the preparation in hydroxide long enough to dissolve out the internal material so that the preparation will be transparent, but not long enough to cause marked bleaching or decoloration of the parts. After soaking the preparation in hydroxide, remove it to distilled water and squeeze out the disintegrated viscera by gentle pressure with needle or forceps. Alternately press and release the abdomen several times; this manipulation will cause a pumping action that will remove most of the internal material. Allow the preparation to soak in a fresh water bath for about a day to remove the last traces of dissolved material. After the washing process, dip the body in 1/50 normal hydrochloric acid to neutralize the remaining hydroxide, and put it in 70 per cent alcohol. Next place the cleared preparation and the appendages previously removed in beechwood creosote. After they have completely cleared and dehydrated, mount them in Canada balsam or clarite.

In mounting the specimen, place the body with the ventral side uppermost and the two palps under one cover located a little to the left of the center of the slide, with sufficient room for the slide label to the left of the cover. Mount one of the palps with the dorsal side uppermost. Remove the chela from the other palp and spread the fingers wide apart. Mount this chela with the external or lateral surface uppermost. If the body and palps are heavy and thick, support the cover glass with short pieces of capillary tubing or short pieces of finely drawn glass rod. Mount the chelicerae and the previously removed legs under a smaller cover to the right of the first. Do not use supports under this cover since the cover glass should rest on the legs and press them out flat for measuring.

After clearing with hydroxide and before

mounting some species or stages that are only lightly sclerotized, stain the body in acid fuchsin. Wash the material in dilute hydrochloric acid before putting it into this stain. After staining, wash the preparation in distilled water for some time to bleach out excess stain; then clear it in beechwood creosote and mount as directed above.

Label all slides clearly, indicating collection data and means of associating slide material with similar material in fluid. When an organism is identified, its name should be put on the slide label.

MORPHOLOGY

As an aid in the use of keys and the accurate identification of species, the important features of the external morphology of pseudoscorpions are outlined below. Additional information is available in the works of Chamberlin (1931a), Beier (1932b, c, d), and Roewer (1936, 1937).

Body

The body of a pseudoscorpion, fig. 7, is divided into two general parts, the cephalothorax and the abdomen. Both the body and the appendages bear many setae, the number and arrangement of which are of considerable taxonomic importance. In many species, the setae are slender and tapering, but in others they are modified in various ways. Commonly some of the setae are divided or branched at the tips and give somewhat club-shaped silhouettes; these setae are spoken of as clavate or subclavate in allusion to their general appearance. In some cases the branching occurs on only one side of a seta, and in others it extends down both sides of the seta to give a feathered effect. The cephalothorax is covered dorsally by a shield or carapace that is without segmentation, although in some cases one or two transverse furrows subdivide the surface of the carapace.

The mouth is at the anterior end of the cephalothorax and the feeding structure is retracted within a cavity in the anterior portion. In most species, one or more pairs of eyes are situated on or near the lateral margin of the cephalothorax; each eye has a single facet.

The abdomen consists of 12 segments, of which the last is greatly reduced and very inconspicuous. In some species, as indicated in fig. 7, the eleventh and twelfth segments

cannot be seen in strict dorsal view. Each segment of the abdomen bears a dorsal tergite and a ventral sternite, but in many forms each of these is divided medially to form lateral sclerites or areas called tergal and sternal halves. The chaetotaxy and sculpturing of the tergites and sternites are often useful in taxonomy. The tergites are usually regular in arrangement and shape, but the anterior sternites are modified as a result of the presence of the genital opening and its accompanying structures. Toward the lateral end of each third and fourth sternite is a stigma or spiracle through which air is taken into the tracheal system. In the males of a few species, the lateral ends of some of the tergites are modified to form keels. A pleural membrane covers the

abdomen laterally between the sternites and tergites.

Appendages

A pseudoscorpion bears six conspicuous pairs of segmented appendages, all arising from underneath the cephalothorax: a short pair of pincer-like chelicerae; an elongate pair of palps, each ending in a pincer-like structure; and four pairs of legs, designated in descriptions by Roman numerals. Unlike most of the members of the Arachnida, the pseudoscorpions lack patellae on their appendages.

Chelicerae.—Each chelicera, fig. 8, is attached near the anterior end of the cephalothorax and consists of a basal segment or podomere extended anteriorly to

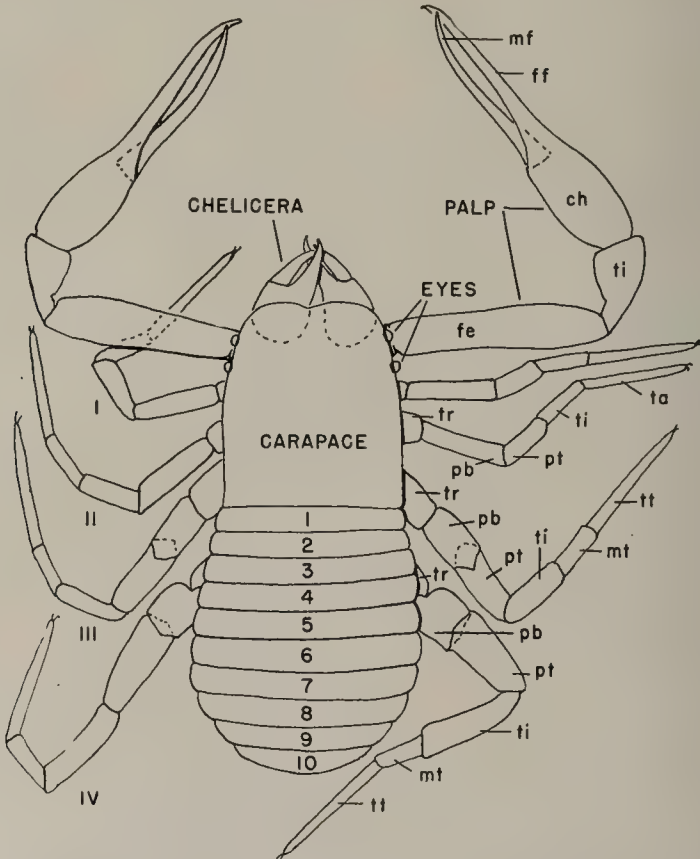


Fig. 7.—Sketch of a heterosphyronid pseudoscorpion to show the general body plan and appendages. The Arabic numerals designate segments of the abdomen; the Roman numerals indicate the four walking legs which arise from under the carapace on the venter of the cephalothorax. Abdominal segments 11 and 12 are not visible in a dorsal view of all species. Abbreviations used are *ch*, chela; *fe*, femur; *ff*, fixed chelal finger; *mf*, movable chelal finger; *mt*, metatarsus; *pb*, pars basalis; *pt*, pars tibialis; *ta*, tarsus; *ti*, tibia; *tr*, trochanter; *tt*, telotarsus. The coxa, which is basad to the trochanter on each leg, is not shown.

form a fixed finger and a second segment to form a movable finger. The dorsal surface of the base of the chelicera bears numerous setae. Those that are of major significance

spicuous galea or spinneret is attached near the end of the movable finger. This galea is said to function in spinning silk discharged from silk gland ducts that open at the tips

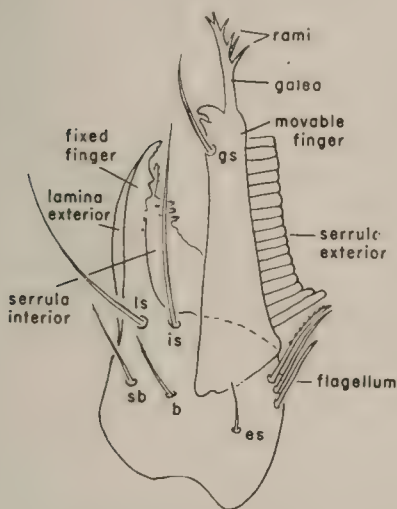


Fig. 8.—*Lamprochernes oblongus* ♀. Exterior or dorsal view of chelicera. The setae important in taxonomy are indicated by the standardized designations: *b*, basal seta; *es*, exterior seta; *gs*, galeal seta; *is*, interior seta; *ls*, laminal seta; *sb*, subbasal seta.

in taxonomy have been designated by letters as shown in fig. 8. The setae vary among species and genera in number, position, and size. The lateral margin of the subventral surface of the cheliceral base bears a flagellum that consists of a few to many modified setae. The fixed finger is usually smaller than the movable cheliceral finger, bears an apical tooth and several denticles along the inner margin, and is supplied with a longitudinal row of plates making up the serrula interior. With exception of the terminal three or four, the plates are frequently fused to form a so-called velum. The outer margin of the fixed finger often bears a longitudinal keel or riblike structure known as the lamina exterior. The movable cheliceral finger has a prominent serrula exterior, consisting of a row of ligulate plates extending along nearly the entire length of the finger. The movable finger terminates in an apical tooth and the inner margin bears either a subterminal lobe or a series of denticles. Near the end of the movable finger is inserted a galeal seta. In some groups, a con-

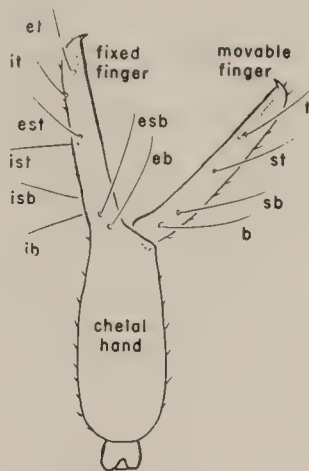


Fig. 9.—*Chelifer cancroides* ♀. Lateral view of chelal hand of palp. The standardized symbols used for the tactile setae of the movable finger are as follows: *b*, basal seta; *sb*, subbasal seta; *st*, subterminal seta; *t*, terminal seta. On the fixed finger, *e* indicates exterior and *i* indicates interior; either is used in connection with *t*, *sb*, and the like. Thus, *et* is the exterior terminal seta, while *it* is the interior terminal seta.

of the galeal branches or rami. When the galea is reduced or wanting, the ducts appear to terminate in a tubercle or directly on the surface near the tip of the finger, fig. 25C.

Palps.—The palps, fig. 7, are the most conspicuous appendages of the animal and are usually extended anteriorly. Each palp consists of several segments or podomeres: the coxa or maxilla, the trochanter, the femur, the tibia, and the chela. The chela has a movable finger that no doubt represents an additional segment. The characteristics of the palpal segments most useful in taxonomy are the general shape, the chaetotaxy and sculpturing, the absolute size, and the length-width ratio. The last is fairly constant within each species and use of it is becoming increasingly important for the separation of closely related species. The segments of the palp, especially the chela, in some cases show sexual dimorphism, the

chela of the male frequently being larger and stouter than that of the female.

The characteristics of the chela, fig. 9, are very important in classification. For a satisfactory study of the chela, a side view must be obtained. In such a view, the inner margins of both the fixed and movable fingers in most cases seem to be supplied with small contiguous teeth. In some cases, however, the teeth are alternately large and small, or variable in different parts of the margin. In the family Chernetidae, accessory teeth are borne on the outer and inner aspects of each finger near the marginal teeth. Great taxonomic significance is attached to the number and arrangement of the tactile setae of the fingers. In most species of pseudoscorpions the fixed finger has eight tactile setae and the movable finger has four, as shown in fig. 9. In other species, the number of tactile setae is greater or smaller. Each tactile seta is identified by the bulbous structure or areola from which it originates. One or both of the chelal fingers terminate in a venedens, or venom tooth, through which the venom is discharged. The venom duct can usually be traced proximally to the nodus ramosus, a dilation at the point where the small ducts form individual venom glands or reservoirs unite to form a single duct.

Legs.—With respect to the legs, several characteristics such as the number of segments, the nature of the joint between the pars basalis and the pars tibialis of the femur, and the nature of the terminal claws and chaetotaxy are important in classification. The number of segments in the legs is used as the basis for dividing the order Pseudoscorpionida into three suborders. In the suborder Monosphyronida, each leg has six apparent segments: coxa, trochanter, pars basalis and pars tibialis of the femur, tibia, and tarsus. In the suborder Diplosphyronida, the tarsus of each leg consists of the proximal metatarsus and the distal telotarsus, so that the leg appears to be made up of seven segments. In the suborder Heterosphyronida, each first and second leg has a single tarsal segment, whereas each third and fourth leg has two tarsal segments. The nature of the legs in the heterosphyronid pseudoscorpions is shown in fig. 7. In general, the legs do not show sexual dimorphism except occasionally in modifications of the tarsal claws of the first leg.

The coxae of the legs are more or less

rigidly attached to the cephalothorax and can easily be seen in ventral view. In some groups of the Heterosphyronida, one or more of the pairs of coxae bear spines. Some species have a minute seta-bearing tubercle located medially between the third and fourth pairs of coxae.

Genitalia

In addition to the structures already described, the genital organs are of some importance in taxonomy. The external genitalia are located on the ventral surface of

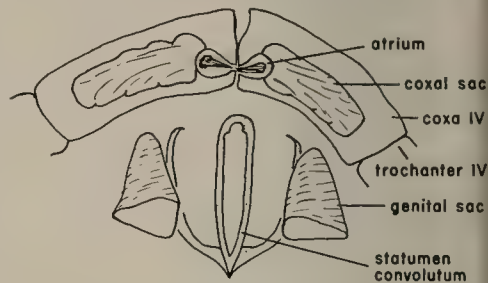


Fig. 10.—*Dactylochelifer copiosus* ♂. Important structures of the male genital complex of the highly specialized type found in the Cheliferidae.

the abdomen in the region of the second and third abdominal segments. The second sternite forms an anterior genital operculum, and the third sternite forms a posterior operculum.

In the female, the genital complex is relatively simple. When better known, it will probably assume greater significance in classification. In some species, a pair of seminal receptacles may be distinguished. These are often in the form of elongated tubules. In many females, perforated plates, known as cribriform plates, are present. The shape, position, and number of these plates are characters used in systematic work. The seminal receptacle and the cribriform plates may be seen in many females cleared with hydroxide.

In the male, the genital complex is more variable than in the female. The chaetotaxy of the opercula can be used on occasion as a specific character. In one group, the subfamily Cheliferinae of the family Cheliferidae, the genital organs of the male are highly modified and specialized, fig. 10. In males of certain genera of this group, each fourth coxa contains a coxal sac either with

or without a separated medial portion known as the atrium. The sclerotized statumen convolutum may or may not be invaginated anteriorly. When an anterior invagination occurs, the invagination contains a short sclerotized rod.

ACKNOWLEDGMENTS

This investigation has been made possible by the encouragement, co-operation, and assistance of many persons and organizations interested in the fauna of Illinois. Co-operative effort has resulted in the accumulation of a greater number of collections of pseudoscorpions than has ever been previously massed together at one time from any one state. The total number of collections made available for this study is about 350, of which two-thirds are from the collections of the Illinois Natural History Survey. Fifty-seven collections were taken by the writer. Other collections were loaned by the Illinois State Museum, the Chicago Natural History Museum, the American Museum of Natural History, the Museum of Comparative Zoology, and the Cornell University Museum. The two museums last named made available type specimens and material collected and recorded from Illinois by H. E. Ewing.

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This study was carried out chiefly while the writer was employed at Quincy College, Quincy, Illinois, continued while he was at the Colorado Agricultural and Mechanical

College, Fort Collins, Colorado, and completed while he was at the University of New Mexico, Albuquerque, New Mexico. Deep appreciation is extended to these institutions and their officials for facilities and time, without which this project could not have been completed. This study was aided also by a grant from the American Association for the Advancement of Science through the Illinois State Academy of Science.

CLASSIFICATION

The order Pseudoscorpionida or Chelone-thida, embracing all of the pseudoscorpions, is set off from other orders of the class Arachnida by the following combination of characters: carapace unsegmented, fig. 7, covering the cephalothorax; abdomen segmented, not divided into pre- and post-abdomen; no sting on the abdomen; chelicerae small and chelate; palps large and chelate; respiration by means of simple tracheae.

The order is divided into three suborders, each of which is represented in the fauna of Illinois. These suborders in turn are divided into a system of superfamilies, families, and lower categories in order to facilitate grouping together related genera and demonstrate as far as possible natural relationships. The general classification followed here is that outlined summarily in papers by Chamberlin (1929*b*, 1930, 1931*a*) and extended or modified by Beier (1932*b*, *c*, *d*). These papers as a group give a comprehensive outline of the classification of the entire pseudoscorpion world fauna, together with full bibliographic treatment of the supergeneric names involved. Material in these papers is not repeated in the present paper, but instead the interested student is referred to them for further study.

The bibliographic citations given in the present paper for species or genera are not intended to be complete. They consist of references to the original description, to papers in which are given diagnoses more nearly complete than the original, to publications that contain important changes in taxonomic position or nomenclature, and to papers that have definite reference to the fauna of Illinois.

In this paper a complete diagnostic characterization of a species is given only for species that are new or for which no recent and complete description is available in the literature. For other species, a summary of

diagnostic characters is given and reference made to available extended descriptions.

Measurements throughout this paper are in millimeters.

Disposition of Material

Most of the Illinois material recorded here and not otherwise noted is in the collection of the Illinois Natural History Survey at Urbana, Illinois. Some material that belongs to other institutions is cited, and this usually is indicated by letters following the record. The letters used are as follows:

CH—Collection of C. Clayton Hoff, University of New Mexico, Albuquerque, N. Mex.

CM—Chicago Natural History Museum, Chicago, Ill.

CR—Collection of C. L. Remington, Yale University, New Haven, Conn.

CU—Cornell University, Ithaca, N. Y.

HV—Collection of H. J. Van Cleave, University of Illinois, Urbana, Ill.

IM—Illinois State Museum, Springfield, Ill.

JC—Collection of J. C. Chamberlin, Forest Grove, Ore.

MCZ—Museum of Comparative Zoology, Harvard College, Cambridge, Mass.

WS—Collection of Willis E. Snow, Urbana, Ill.

Systematic List

To date there are Illinois records for 26 species of pseudoscorpions. Of these, two are known only on the basis of literature records. They are indicated by an asterisk in the following list.

Suborder HETEROSPHYRONIDA

Family TRIDENCHTHONIIDAE

Subfamily Tridenchthoniinae

Tribe Verrucadithini

Verrucaditha spinosa (Banks)

Family CHTHONIIDAE

Subfamily Chthoniinae

Tribe Chthoniini

**Chthonius ischnocheles* (Hermann)

Chthonius tetrachelatus (Preysler)

Apochthonius moestus (Banks)

Heterochthonius multispinosus Hoff

Mundochthonius rossi new species

Mundochthonius sandersoni new species

Suborder DIPLOSPHYRONIDA

Family NEOBISIIDAE

Subfamily Neobisiinae

Microbisium brunneum (Hagen)

Microbisium confusum Hoff

Family GARYPIDAE

Larca granulata (Banks)

Suborder MONOSPHYRONIDA

Family CHERNETIDAE

Subfamily Lamprochernetinae

Lamprochernes oblongus (Say)

Lamprochernes minor new species

Subfamily Chernetinae

Parachernes squarrosus new species

Pselaphochernes parvus Hoff

Reginachernes ewingi new species

Reginachernes lymphatus new species

Dinocheirus pallidus (Banks) new combination

Dinocheirus solus new species

Acuminochernes crassopalpus (Hoff) new combination

Mirochernes dentatus (Banks)

Illinichernes distinctus new species

**Chelanops* (?) *corticis* Ewing

Family CHELIFERIDAE

Subfamily Cheliferinae

Tribe Cheliferini

Chelifer cancroides (Linnaeus)

Idiochelifer nigripalpus (Ewing)

Paisochelifer callus (Hoff)

Tribe Dactylocheliferini

Dactylochelifer copiosus Hoff

The keys to suborders, superfamilies, and families are designed to accommodate the entire fauna known at present from America north of Mexico. Where used, the subfamily keys are designed for the same fauna. Keys to tribes and genera are intended primarily to resolve the fauna of the central and eastern United States and adjoining portions of Canada. Keys to species include those taken in Illinois and in addition a few species that are known from surrounding states and that ultimately may be found in this state.

KEY TO SUBORDERS

- Each first and second leg with five segments exclusive of the coxa, and each third and fourth leg with six segments exclusive of the coxa, fig. 7..... **Heterosphyronida**, p. 429
All legs with the same number of segments..... 2
- Tarsus of each leg divided into metatarsus and telotarsus, so that the leg has six segments exclusive of the coxa..... **Diplosphyronida**, p. 443

Tarsus of each leg not divided, so that the leg has five segments exclusive of the coxa.....**Monosphyronida**, p. 449

Suborder **HETEROSPHYRONIDA**

Members of this suborder may be recognized by the single tarsal segment in the first and second legs and the two tarsal segments in the third and fourth legs. Both families represented in North America are known from Illinois. Both may be recognized by the extremely large chelicerae, fig. 11, as well as by the key characters.

KEY TO FAMILIES

Most abdominal tergites with a double row of closely spaced, short and stout setae extending completely across each segment; respiratory spiracles of third and fourth sternites obliquely placed and with differentiated guard sclerites, fig. 12E; body and palps very setose and granular; spines on coxae I and II, fig. 12D **Tridenchthoniidae**, p. 429

Abdominal tergites with only a single row of long and slender setae across each segment; respiratory spiracles of third and fourth sternites transversely placed and without guard sclerites differentiated from the sternites, fig. 15D; body and palps no more than weakly granular; Illinois species with spines on coxa I, fig. 15C, on coxa II, or on coxae II and III..... **Chthoniidae**, p. 431

TRIDENCHTHONIIDAE

Pseudoscorpions belonging to this group can be recognized by the obliquely placed stigmata or respiratory spiracles, fig. 12E, that are guarded by well-developed sclerites. Some exotic genera have only a single row of stout setae across the abdominal tergites.

In America north of Mexico the family is represented by a single genus, *Verrucaditha*. Diagnosed in relation to the world fauna by Chamberlin & Chamberlin (1945), this genus is placed in the subfamily Tridenchthoniinae and tribe Verrucadithini.

1. **VERRUCADITHA** Chamberlin

Alura Chamberlin (1926, p. 334). Genotype, by original designation: *Chthonius spinosus* Banks. (Name preoccupied by *Alura* Moeschler 1883.)

Verrucaditha Chamberlin (1929b, p. 59). New name for *Alura* Chamberlin.

Verrucaditha Chamberlin. Chamberlin & Chamberlin (1945, p. 22).



Fig. 11.—*Apochthonius moestus*, an example of the suborder Heterosphyronida and the family Chthoniidae.

Members of this genus possess movable chelal fingers on which the marginal teeth are broad, rounded, and contiguous. Only one nearctic species is known.

Verrucaditha spinosa (Banks)

Chthonius spinosus Banks (1893, p. 67).

Verrucaditha spinosa (Banks). Chamberlin (1929b, p. 59), Chamberlin & Chamberlin (1945, p. 24), Hoff (1946b, p. 103).

In general, the following combination of characteristics serves to identify adults without mounting: body length 1.0–1.3 mm.; carapace with about 100 heavy lanceolate investing setae, fig. 12B, and with the anterior carapacic margin distinctly bilobed; the pair of tactile setae on the dorsum of each chelal hand removed from the proximal margin of the hand by about one-fourth its length, figs. 12A, 12C; spines on coxae I and II, fig. 12D. For more extensive descriptions of this species, the reader is referred to Chamberlin & Chamberlin (1945) and Hoff (1946b).

DEUTONYMPH.—The following description is based on one individual. This stage has not been described previously in the literature. The deutonymph in general resembles the adult, length 0.82 mm., greatest width of abdomen 0.35 mm. Carapace anteriorly bilobed, each lobe with four stout marginal setae; eyes conspicuous. Chelicera very similar to that of the tritonymph as previously reported (Hoff 1946b) except that there are three rather than two galea-like processes near the end of the movable

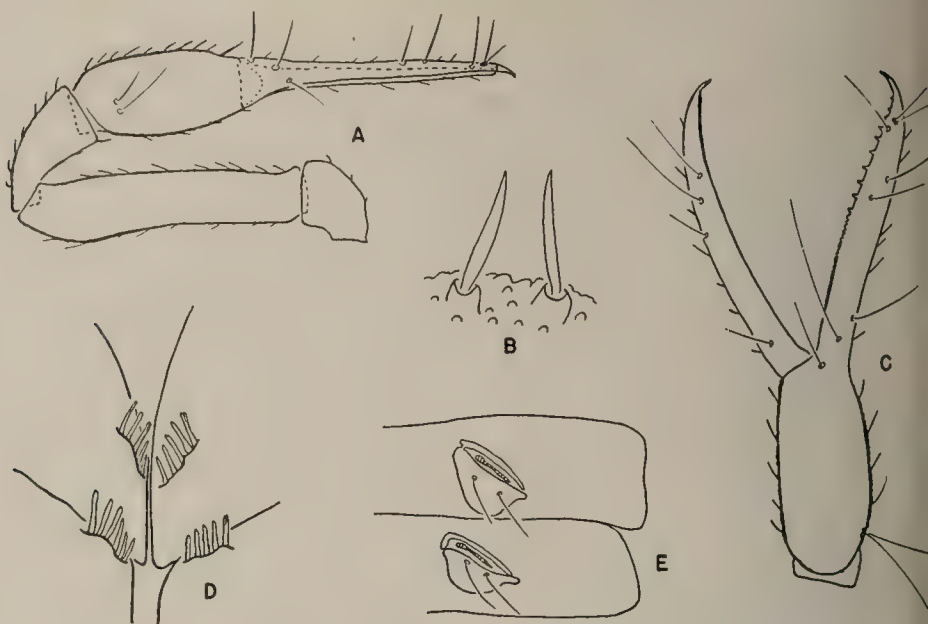


Fig. 12.—*Verrucaditha spinosa*. A, dorsal view of palp ♂; B, setae of carapace; C, exterior view of chela, ♂; D, coxal spines, ♂. E, stigmata or respiratory spiracles, ♀.

finger and 10 rather than 14 plates in the serrula exterior. Three to five spines occur on each of coxae I and II. Segments of palps weakly granulate and light yellow in color. Palp with femur 0.205 mm. long, 0.07 mm. wide; tibia 0.125 mm. long, 0.075 mm. wide; chela 0.4 mm. long, 0.082 mm. wide; depth of hand equal to width, length about 0.13 mm.; movable finger 0.26 mm. long. Fixed chelal finger with seven tactile setae, *ds* and *et* near distal end, *it* and *est* near center, two setae near base of finger, and one (*isb* or *ib*) a little proximad to the mid-point of the dorsum of the hand; movable finger with two tactile setae near center. Marginal teeth similar in appearance to those of the adult; movable finger with 24 marginal teeth; fixed finger with 11 acute and well-separated teeth in the distal half of the finger and 10 more nearly contiguous teeth on the proximal half of the finger margin.

DISTRIBUTION.—*Verrucaditha spinosa* does not occur abundantly in Illinois. Of eight records, four are from Adams County and one each from Brown, Jackson, Jersey, and Madison counties. The species is widely distributed in the central and southeastern part of the United States as shown by existing records (Chamberlin & Chamberlin 1945).

This species usually occurs in debris and decaying wood of old stumps and logs in deciduous forests. One collection was taken from "ground cover" and one from fallen needles under an eastern redcedar tree (*Juniperus virginiana* Linnaeus).

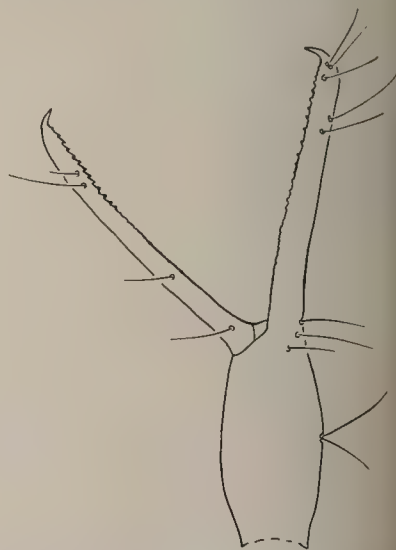


Fig. 13.—*Chthonius ischnocheles*. Lateral view of chela. (After Chamberlin.)

Illinois Records.—ADAMS COUNTY: 1943, G. C. Hoff, 1 ♂; Coe's Spring, Oct. 28, 1944, Rev. Edbert Long, 1 ♂, 2 ♀ (1 ♂, 1 ♀, CH). EDWARDSVILLE: Sept. 24, 1943, Ross & Sanderson, 1 immature. GRAFTON: Sept. 30, 1943, Ross & Sanderson, 1 ♂. MAKANDA: Oct. 12, 1933, Frison & Ross, 1 ♂. QUINCY: southwest of, July 8, 1944, C. C. Hoff, 1 immature (CH); south of, July 8, 1944, C. C. Hoff, 1 ♂. SILOAM: Siloam Springs, Aug. 29, 1945, C. C. Hoff, 1 immature (CH).

CHTHONIIDAE

Species belonging to this family may be recognized by the transversely placed spiracles that are not accompanied by separate guard sclerites, fig. 15*D*. All four Illinois genera belong to the subfamily Chthoniinae and the large tribe Chthoniini. Members of this tribe possess two tactile setae (*isb* and *ib*), figs. 14*A*, 15*A*, in a transverse pair on the dorsum of each chelal hand.

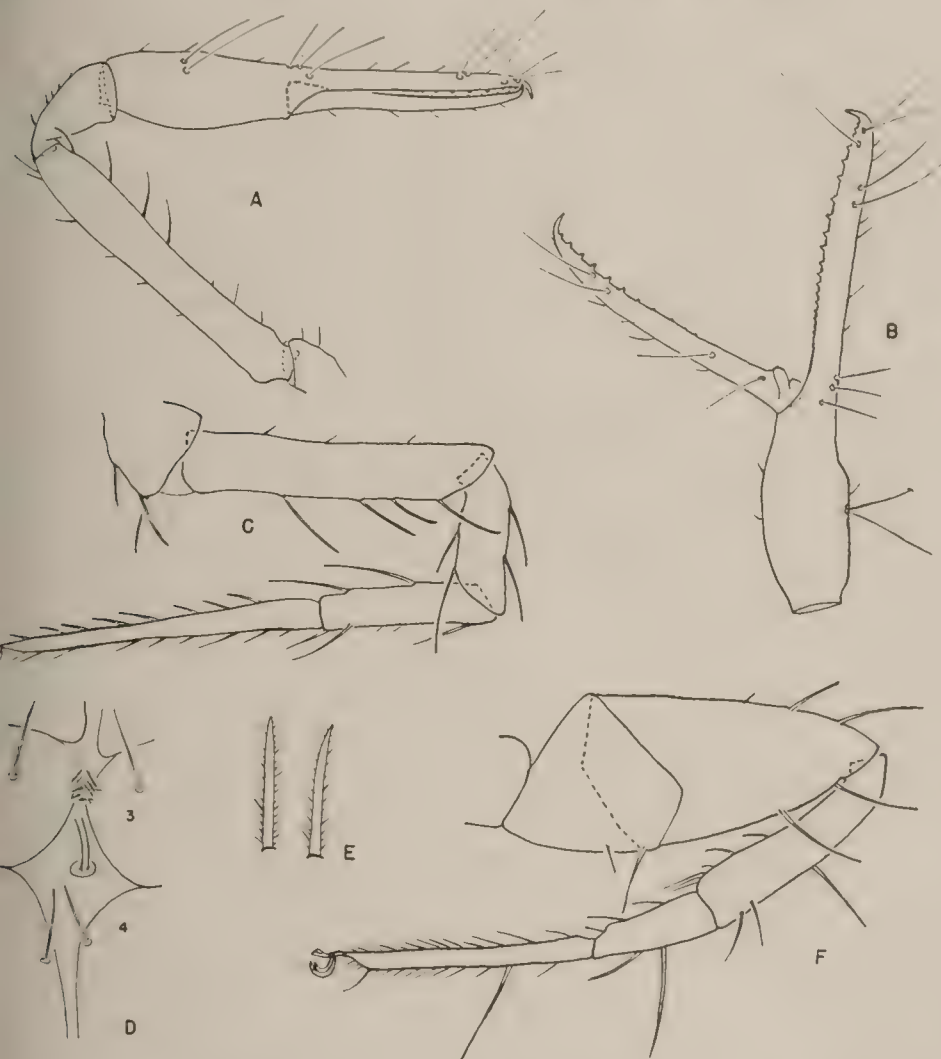


Fig. 14.—*Chthonius tetrachelatus*. A, dorsal view of palp, ♂; B, external view of chela, ♂; C, first leg, ♂; D, parts of coxae II, III, and IV, showing the spines of coxa III and the tubercle and setae, ♀; E, two isolated coxal spines enlarged to show structure, ♂; F, fourth leg, ♂, drawn to a much smaller scale than first leg, C. If the specimen is shrunk in mounting, the tubercle and setae in D are difficult to see.

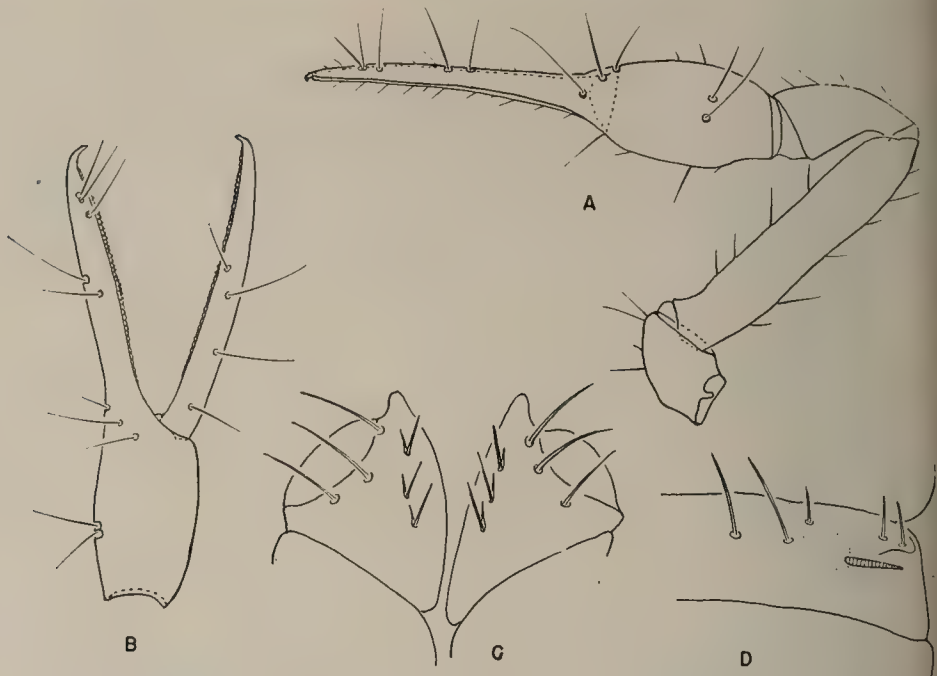


Fig. 15.—*Apochthonius moestus*. A, palp in dorsal view, ♀; B, chela in lateral view, ♀; C, spines of coxa I, ♀; D, stigma on sternite 3, ♀.

KEY TO GENERA

1. Eyes absent; body length 2.3 mm.....
.....**6. Genus? packardi**
- Eyes present, or, if wanting or vestigial,
body length less than 1.5 mm.....2
2. Mesal portion of coxa I containing a group
of well-separated spines, often in a row,
each spine arising from an elongate slit,
fig. 15C; intercoxal tubercles not present
on the mid-line between any of the
coxae.....3
- Mesal portion of coxa I without such
spines; instead a comb of short spines
or a group of short, feathered spines
present on the mesal region of coxa II or
coxae II and III, figs. 14D, 17E; a
minute intercoxal tubercle bearing two
small setae present between the junction
of coxae III and IV.....4
3. Teeth along margins of chelal fingers short
and broad, arranged close together,
fig. 15B.....**3. Apochthonius**
- Chelal teeth widely spaced, alternately
large and small, fig. 16C.....
.....**4. Heterochthonius**
4. A group of well-separated, short, feathered
spines present on each mesal margin of
coxae II and III, figs. 14E, 14D.....
.....**2. Chthonius**
- Short coxal spines in the form of a comb,
frequently united at bases, present only

on the mesal portion of coxa II, figs.
17D, 18D.....**5. Mundochthonius**

2. *CHTHONIUS* C. Koch

Chthonius C. Koch (1843, p. 76). Genotype,
by subsequent designation of Simon (1879):
Obisium orthodactylum Leach.

Chthonius C. Koch. Chamberlin (1929b, p.
69), Chamberlin (1931a, p. 212), Beier
(1932b, p. 43).

The genus *Chthonius* is characterized by
the presence of an intercoxal tubercle, spines
on coxae II and III, and simple teeth (not
always contiguous) on the inner margins of
the chelal fingers, figs. 14B, 14D. Several
subgenera have been outlined in the liter-
ature. Of these subgenera, two are repre-
sented in Illinois, each by one species. Other
species in the genus are known from
Georgia, North Carolina, and California.

KEY TO SUBGENERA AND SPECIES

Teeth of inner margins of chelal fingers large,
acute, uncrowded, and somewhat conical
and recurved; chelal hand appearing evenly
rounded on the dorsal margin as viewed
from the side, fig. 13. Subgenus *Chthonius*
.....**ischnocheles**

Teeth of inner margins of chelal fingers long and pointed, often well separated; in lateral view, the chelal hand displays a depression between the tactile seta of the dorsum of the hand and the finger base, fig. 14B. Subgenus *Ephippiochthonius*..... **tetrachelatus**

Subgenus *Chthonius* C. Koch

Chthonius s. str. C. Koch. Beier (1932b, p. 47).

Members of this subgenus may be recognized by the large, acute, and retroconical (pointing toward the base of the finger) marginal teeth of the chelal fingers. The marginal teeth in some species are well separated, at least in the distal part of the fixed finger. The chelal hand has an evenly rounded contour as viewed from the side, there being no dorsal depression near the base of the fixed finger. A single species of the subgenus has been taken in the Illinois fauna.

Chthonius ischnocheles (Hermann)

Chelifer ischnocheles Hermann (1804, p. 113).

Chthonius Pennsylvanicus Hagen (1869, p. 52).

Chthonius pennsylvanicus Hagen. Ewing (1911, p. 80).

Chthonius ischnocheles (Hermann). Chamberlin (1929b, p. 71).

Chthonius (Chthonius) ischnocheles (Hermann). Beier (1932b, p. 48).

The species can be recognized from the characters given in the keys. The following additional characters are listed by Beier (1932b). Cephalothorax with 20 to 24 setae, the posterior margin with four to six equally long setae. Setae of the tergites: 4:4:4:4:6:6:6:6. Marginal teeth of the palpal fingers pointed, triangular in outline, and directed somewhat toward the base of the finger, fig. 13. Teeth of movable finger almost as strong as those of the fixed finger. Coxa II with at least 14 spines, coxa III with at least 9 spines. Intercoxal tubercle with two setae. Body length 1.6-2.4 mm.; palpal hand 0.5 mm. long, 0.27 mm. wide; finger length 0.85 mm.

DISTRIBUTION.—Ewing (1911) reported a single individual of this species from Hillery, Vermilion County, Illinois. No additional collections have been secured in our recent survey. The species has a wide distribution and is reported from many localities in Europe and from the northeastern part of the United States (Chamberlin 1929b). More Illinois records of this species would be useful.

Subgenus *Ephippiochthonius* Beier

Ephippiochthonius Beier (1930a, p. 323).

Genotype, by present designation: *Scorpio tetrachelatus* Preyssler.

Members of this subgenus are recognized by the presence of 18 setae on the carapace, of which two are on the posterior margin; in lateral view, the chelal hand displays a depression between the tactile setae of the dorsum of the hand and the finger base, fig. 14B; teeth of chelal fingers are long, pointed, and usually well separated. A single species has been taken in Illinois.

Chthonius tetrachelatus (Preyssler)

Scorpio tetrachelatus Preyssler (1790, p. 59).

Chthonius tetrachelatus var. *maculatus* Menge. Stecker (1875, p. 314).

Chthonius longipalpus Banks (1891, p. 164).

Chthonius longipalpus Banks. Ewing (1911, p. 80).

Chthonius tetrachelatus (Preyssler). Vachon (1941a, p. 442).

Chthonius (Ephippiochthonius) tetrachelatus (Preyssler). Hadzi (1933a, p. 139; 1933b, p. 179), Hoff (1946b, p. 109).

Individuals of this species may be recognized by the characteristics given in the key, especially by the shape of the chelal hand and the nature of the marginal teeth of the chelal fingers, fig. 14B. No detailed description is included here, since the species has been treated recently and adequately by Hadzi (1933a, 1933b) and Vachon (1941a, 1941b). The adults and most nymphs (but not the protonymph) in our collections agree well with those described by Vachon, except that the palpal segments of our specimens appear to be a little more slender than indicated in Vachon's drawings.

I have examined a single protonymph that apparently belongs to this species. Unfortunately, this protonymph was not associated with adults and, as a result, the identification may be questioned. The individual differs radically from the form described by Vachon (1941a; 1941b) as the protonymph of *tetrachelatus*. Possibly Vachon studied the last larval stage rather than the first nymphal stage, or protonymph, since his drawings do not appear to be made of animals sufficiently developed to be protonymphs. Because of limited material and questionable identification, the protonymph I have examined that apparently belongs to this species is not described here.

DISTRIBUTION.—*Chthonius tetrachelatus* was taken by the writer in 11 collections in

the vicinity of Quincy, Adams County. In addition, a single individual was present in a collection made by Henry Dybas near Mooseheart, Kane County. The only other record available is from Herod, Pope County, and consists of the questionable protonymph mentioned above. The species has a wide distribution in Europe and north-east Africa and has been reported from the New England states and Indiana in the United States (Chamberlin 1929*b*).

Ecological data are available only for the collections taken in Adams County. Here the species was found chiefly in debris and leaf mold in woods, frequently in the vicinity of limestone outcroppings along the bluffs of the Mississippi River.

Illinois Records.—HEROD: Oct. 12, 1933, ground cover in woods, Frison & Ross, 1 protonymph. MOOSEHEART: Sept. 1, 1939, Henry Dybas, 1 specimen (CM). QUINCY: Oct. 10, 1943; Nov. 1, 1943; July 2, 1944; July 29, 1944; Aug. 13, 1944; all by C. C. Hoff, many specimens.

3. *APOCHTHONIUS* Chamberlin

Apochthonius Chamberlin (1929*b*, p. 66).

Genotype, by original designation: *Chthonius moestus* Banks.

Apochthonius Chamberlin (1929*c*, p. 152).

Apochthonius Chamberlin: Beier (1932*b*, p. 41).

The genus includes pseudoscorpions with the following characteristics: 22 to 24 setae on the carapace; four eyes; each coxa I with three simple seta-like coxal spines, each spine originating from a cleft or fissure on the surface of the coxa, fig. 15*C*; intercoxal tubercle lacking; chelicera with seven setae on the hand; marginal teeth of the chelal fingers small, contiguous, and occupying nearly the full length of the finger margins, fig. 15*B*. One species, *moestus*, occurs in eastern North America; two others in the north Pacific Coast region, *occidentalis* Chamberlin and *intermedius* Chamberlin.

Apochthonius moestus (Banks)

Chthonius moestus Banks (1891, p. 165).

Apochthonius moestus (Banks). Chamberlin (1929*b*, p. 67), Hoff (1944*a*, p. 125; 1945*c*, p. 311; 1946*b*, p. 105).

This species can be separated easily from other Illinois pseudoscorpions by the three coxal spines on each coxa I and by the small and contiguous marginal teeth on the chelal fingers. Diagnostic characteristics are illustrated in figs. 11 and 15.

DISTRIBUTION.—*Apochthonius moestus* is widely distributed over Illinois; it has been identified in 65 collections from various parts of the state. The species appears to be distributed over most of the United States east of the Great Plains region.

One of the more common pseudoscorpions in the eastern and central states, *moestus* is found very abundantly in the litter and debris on the ground in deciduous woods. It has also been taken from beneath the bark of decaying logs, in moss, and in mammal nests.

Illinois Records.—Many specimens, taken throughout the year, are from Alhambra, Alto Pass, Anna, Bond County, Burksville, Cadiz, Charleston, Collinsville, Danville, Dolson (Clarksville), Eichorn, Fountain Bluff, Ganntown, Geff, Giant City State Park, Grafton, Herod, Kellerville, La Rue (Wolf Lake), Marshall, Monticello, New Salem State Park, Oakwood, Pocahontas, Quincy, Sherman, Starved Rock State Park, Urbana, Vienna, West Vienna, and White Heath.

4. *HETEROCHTHONIUS* Chamberlin

Heterochthonius Chamberlin (1929*c*, p. 153).

Genotype by original designation: *Apochthonius* (*Heterochthonius*) *crobyi* Chamberlin.

Heterochthonius Chamberlin. Hoff (1945*c*, p. 313).

The members of this genus are similar to members of the genus *Apochthonius* but differ in having the marginal teeth of the chelal fingers with at least the distal teeth well separated and typically composed of alternating large and small teeth; coxa I with three to six spines; carapace with 20 to 24 setae. Only two species are known in the genus, both from the eastern half of the United States, but only one is recorded from Illinois.

KEY TO SPECIES

Body length 1.6–2.0 mm.; length-width ratio of palpal femur greater than 4:5, usually greater than 5:0.....**multispinosus**
Body length 1.3 mm.; length-width ratio of palpal femur 3:8.....**crobyi**

Heterochthonius multispinosus Hoff

Heterochthonius multispinosus Hoff (1945*c*, p. 314).

This is the only pseudoscorpion thus far found in Illinois that has four to six (in one specimen, three) spines on each coxa I and

the marginal teeth of the chelal fingers well spaced and alternately large and small, figs. 16B, 16C.

MALE.—The present individuals agree well with the type specimens. A study of specimens from Duke Forest, the type locality, and from Illinois shows that much greater variation occurs than was indicated in the study of the restricted type material. The following measurements and observations are based on five males from Illinois. Body length 1.65–1.85 mm.; carapace 0.46–0.51 mm. long, 0.43–0.47 mm. wide; abdomen 1.15–1.35 mm. long, 0.65–0.7 mm. wide. Chelicera 0.33–0.39 mm. long, base 0.19–0.24 mm. wide; movable finger 0.2–0.235 mm. long; serrula exterior with 16 to 18 ligulate plates. Palp with trochanter 0.21–0.215 mm. long, 0.12–0.125 mm. wide; femur 0.65–0.73 mm. long, 0.12–0.13 mm. wide, length 5.4 to 5.65 times the width (ratio of 5.1:1 in type specimens, but ratio in other Duke Forest specimens similar to that in many individuals from Illinois); tibia 0.26–0.29 mm. long, 0.13–0.145 mm. wide, length 1.9 to 2.05 times the width; chela 0.93–1.05 mm. long, 0.185–0.2 mm. wide, length 5.0 to 5.25 times the width; chelal hand 0.37–0.42 mm. long, 0.195–0.205 mm. deep; movable chelal finger 0.56–0.65 mm. long (a little less than in the type specimens) and light yellow in color (not reddish-brown as given in the original description). First leg with pars basalis 0.36–0.4 mm. long, 0.07–0.075 mm. deep; pars tibia 0.16–0.195 mm. long, 0.065–0.073 mm. deep; tibia 0.21–0.24 mm. long, 0.05–0.057 mm. deep; tarsus 0.4–0.43 mm. long, 0.045–0.05 mm. deep. Fourth leg with entire femur 0.57–0.63 mm. long, pars basalis 0.2–0.23 mm. deep; pars tibia 0.18–0.215 mm. deep; tibia 0.37–0.425 mm. long, 0.08–0.087 mm. deep; metatarsus 0.2–0.225 mm. long, 0.65–0.70 mm. deep; telotarsus 0.39–0.45 mm. long, 0.04–0.044 mm. deep; tactile seta removed from the proximal margin of the tarsus by 0.12–0.13 mm., being farther removed from the proximal margin than indicated for the type material (Hoff 1945c).

FEMALE.—In general, the female resembles the male except that the body and appendages are longer and that many of the segments of the appendages are stouter. The following measurements are of two females, each measurement of one followed in parentheses by the corresponding measurement of the other. Body length 1.98 (1.85) mm.;

carapace 0.53 (0.55) mm. long, 0.49 (0.52) mm. wide; abdomen 1.45 (1.28) mm. long, 0.56 (0.7) mm. wide. Chelicera with finger 0.285 (0.26) mm. long, serrula exterior with 17 (19) plates. Palp with trochanter 0.26 (0.26) mm. long, 0.145 (0.145) mm. wide; femur 0.81 (0.79) mm. long, 0.156 (0.15) mm. wide; tibia 0.335 (0.31) mm. long, 0.175 (0.16) mm. wide; chela 1.18 (1.15) mm. long, 0.245 (0.245) mm. wide; chelal hand 0.495 (0.48) mm. long, 0.255 (0.25) mm. deep; chelal finger 0.7 (0.68) mm. long. First leg with pars basalis 0.425 (0.405) mm. long, 0.087 (0.078) mm. deep; pars tibia 0.2 (0.—) mm. long, 0.08 (0.08) mm. deep; tibia 0.255 (0.25) mm. long, 0.061 (0.062) mm. deep; tarsus 0.46 (0.43) mm. long, 0.053 (0.051) mm. deep. Fourth leg with pars basalis 0.255 (0.22) mm. deep; pars tibia 0.24 (0.2) mm. deep; entire femur 0.7 (0.67) mm. long; tibia 0.475 (0.44) mm. long, 0.105 (0.09) mm. deep; metatarsus 0.258 (0.24) mm. long, 0.08 (0.07) mm. deep; telotarsus 0.48 (0.46) mm. long, 0.053 (0.045) mm. deep; tactile seta 0.13 (0.135) mm. from proximal margin of tarsus.

TRITONYMPH.—Much like the adult but smaller and segments of the appendages stouter. Body about 1.4 mm. long; carapace with both length and width about 0.4 mm.; abdomen 1.1 mm. long, about 0.65 mm. wide. Chelicera with movable finger stouter than in the adult and with a subterminal nodule in which terminate a number of gland ducts; serrula exterior with 16 ligulate plates; movable finger 0.18 mm. long, basal setae apparently fewer than in the adult. Palpal segments conspicuously stouter than in the adult, color a little lighter, setae not so strongly developed. Palp with trochanter 0.19 mm. long, 0.1 mm. wide; both femora 0.5 mm. long, one femur 0.115 mm. wide, the other 0.12 mm. wide; tibia 0.215 mm. long, about 0.13 mm. wide; chela 0.78 mm. long, 0.175 mm. wide; chelal hand 0.29 mm. long, 0.17 mm. deep; movable finger 0.51 mm. long. Marginal teeth of chelal fingers much as in the adult except fewer in number on the fixed finger and with less difference in size between the alternating large and small teeth. Movable finger with three tactile setae: *st* not much distad from the mid-point of the finger, *t* about two areolar diameters distad from *st*, *b* removed from the proximal finger margin by less than twice the width of the finger at the level

of *b*. Fixed finger with *est* about midway between *ist* and the finger tip; *it* about three areolar diameters distad from the level of *est*; other setae much as in the adult except one of the setae on the dorsum of the chelal hand is wanting. The segments of the legs generally shaped as in the adult except much smaller and stouter; telotarsus of fourth leg subfusiform. First leg with pars basalis 0.258 mm. long, 0.066 mm. deep; pars tibialis 0.133 mm. long, 0.061 mm. deep; tibia 0.145 mm. long, 0.048 mm. deep; telotarsus 0.285 mm. long, 0.042 mm. deep. Fourth leg with entire femur 0.42 mm. long, 0.158 mm. deep; tibia 0.285 mm. long, 0.072 mm. deep; metatarsus 0.152 mm. long, 0.06 mm. deep; telotarsus 0.292 mm. long, 0.046 mm. deep; tactile seta removed from the proximal margin of the telotarsus by about 0.075 mm.



Fig. 16.—*Heterochthonius multispinosus* ♂. A, chela, dorsal view; B, chela, lateral view; C, more distal marginal teeth of chela.

DISTRIBUTION.—This species is infrequent in Illinois, having been taken in only four collections. Two of these collections were from Pope County, one from Jackson County, and one from Hardin County. The only other record is from Duke Forest, Durham, North Carolina, the type locality. The number of specimens found in the Illinois collections is small: four males, two females, and one tritonymph.

This species has been taken only from ground cover, both in Illinois and in North Carolina.

Illinois Records.—CADIZ: Nov. 6, 1942, Ross & Sanderson, 2♂, 1♀. FOUNTAIN BLUFF: Feb. 22, 1933, Ross & Mohr, 1 immature. HEROD: Oct. 12, 1933, Frison & Ross, 2♂ (1♂, CH); Oct. 18, 1944, Ross & Sanderson, 1♀.

Heterochthonius crosbyi (Chamberlin)
Apochthonius (*Heterochthonius*) *crosbyi* Chamberlin (1929c, p. 153).

This species is known only from North Carolina, but may eventually be found in Illinois.

Recently the writer has been able, through the kindness of Henry Dietrich of the Cornell University Agricultural Experiment Station, to examine the holotype of *Heterochthonius crosbyi*. A comparison of *crosbyi* and *multispinosus* indicates that *crosbyi* is much smaller than *multispinosus* and that there is no possibility of confusing the two species. The following measurements were secured of the type of *crosbyi* and serve to supplement descriptive material given in the literature: body length 1.3 mm. (not 1.5 mm. as recorded in the original description, Chamberlin 1929c); each palp with femur 0.5 mm. long and 0.13 mm. wide; chela somewhat damaged but apparently about 0.78 mm. long; movable chelal finger 0.54 mm. long.

5. *MUNDOCHTHONIUS* Chamberlin

Mundochthonius Chamberlin (1929b, p. 64).

Genotype, by original designation: *Mundochthonius erosidens* Chamberlin.

Mundochthonius Chamberlin. Beier (1932b, p. 36).

Members of the genus *Mundochthonius* may be recognized by the simple chelal teeth; each tergite with usually four to eight setae; intercoxal tubercle with two setae; only coxa II with spines, figs. 17D, 17E. Previously, the genus was known from a number of species recorded from the western United States and from Japan. The two Illinois species described below constitute the first records of this genus east of the Rockies in North America.

KEY TO SPECIES

Palpal femur longer than 0.3 mm.; chela longer than 0.5 mm.; length of palpal chela (with an occasional exception) at least 4.2 times the width; mesal comb of coxa II irregularly fused at base, figs. 17D, 17E *rossi*
Palpal femur always shorter than 0.3 mm.; chela shorter than 0.5 mm.; length of palpal

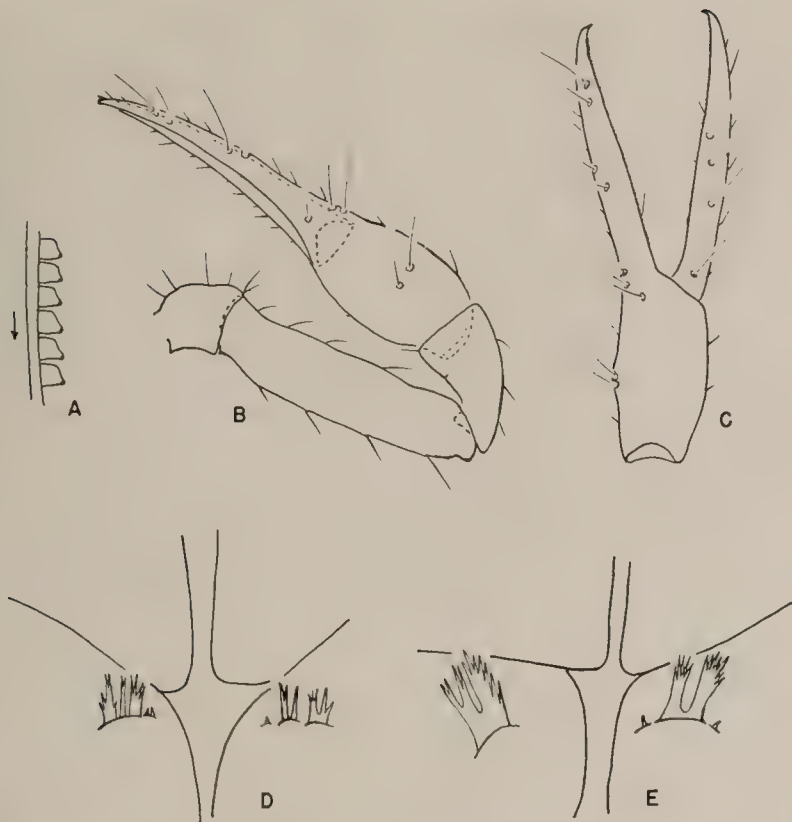


Fig. 17.—*Mundochthonius rossi*. A, teeth of distal part of margin of fixed chelal finger, holotype, ♂, arrow points proximad; B, dorsal view of palp, paratype, ♂; C, lateral view of chela, holotype, ♂; D, spines of coxa II, paratype, ♀; E, spines of coxa II, allotype, ♀.

chela always less than 4.2 times the width; mesal comb of coxa II fused symmetrically at base to form a fan-shaped structure, fig. 18D.....*sandersoni*

Mundochthonius rossi new species

Individuals of this species may be recognized by characteristics given in the key and illustrated in figs. 17B, 17D.

MALE.—Unless otherwise indicated, observations and measurements are based on four individuals. Body and palps light yellow in color; body and appendages moderately slender; body length 1.05–1.2 mm. Carapace subquadrate; two very weakly developed eyes, each located about its own diameter from the anterior carapacic margin; eyes hardly discernible in caustic-treated individuals. Anterior margin of carapace medially serrate with a small triangular, but variable, epistome; anterior margin of carapace with six setae, of which

the farthest lateral one of each side is located a little distance from the actual carapacic margin and close to the eye; posterior margin of carapace with two setae; total setae on carapace 18; carapace smooth except for netlike markings on the sides and sometimes along the posterior margin; carapace narrowed a little toward the anterior end, sides slightly convex; length of carapace 0.38–0.41 mm.; width a little greater than the length, 0.385–0.415 mm.; ocular width 0.38–0.39 mm. Tergites 1 and 2 each with four setae, tergites 3 through 9 each with six setae; tergites almost smooth, undivided. Medial setae of sternites much longer than lateral setae. Pleural membranes with regular rows of fine punctations. Length of abdomen 0.7–0.8 mm., greatest breadth 0.41–0.48 mm.

Chelicera.—A little darker than the carapace; base with six setae, almost smooth. Length of chelicera 0.27–0.29 mm., width

of base 0.155–0.16 mm. Fixed finger basally stout, terminally narrowed and acute; tip of apical tooth brown and sclerotic; inner margin of finger with about 10 conical and acute denticles, usually the distal first and third much larger than the others. Movable finger moderately stout, gently curved, especially near the tip; tip of apical tooth brown and sclerotic; spinneret represented by a rounded and poorly developed knob, apparently without gland ducts; galeal seta near the mid-point of the finger; inner margin of movable finger with about eight denticles, much like those of the other finger in general appearance; serrula exterior with 13 to 15 ligulate plates; length of movable finger about 0.16 mm.

Palp.—Fig. 17B. Moderately stout, chela slender; surface of segments smooth. Measurements given as the limits of range secured from four mounted individuals. Trochanter with flexor margin flatly convex in the center and with a few long setae; 1.5–1.7 mm. long, 0.92–0.103 mm. wide; length 1.6 to 1.7 times the width. Femur subcylindrical, extensor margin weakly convex or nearly straight in middle, more convex near the ends; flexor margin slightly convex beyond the mid-point; setae of the flexor surface much longer than those of the extensor surface; 0.345–0.365 mm. long, greatest width just distad from the mid-point and equal to 0.085–0.09 mm., length between 4.0 and 4.15 times the width. Tibia with a few long and slender setae, especially on the extensor surface; outer margin convex, inner margin weakly concave to straight; widest across the extreme distal end; 0.177–0.2 mm. long (usually greater than 0.19 mm.), 0.105–0.11 mm. wide; length between 1.65 and 1.85 times the width. Chela with hand rather stout and fingers slightly curved; both margins of hand evenly convex, but with the flexor margin in most individuals conspicuously more convex than the extensor; chela 0.55–0.585 mm. long, 0.122–0.132 mm. wide, length 4.4 to 4.5 times the width; chelal hand 0.203–0.21 mm. long; depth of hand nearly equal to the width; movable finger 0.36–0.385 mm. long. Viewed from the side, chelal hand, fig. 17C, with ventral margin moderately and evenly convex; dorsal margin slightly convex, especially in the region of the tactile setae of the dorsum of the hand; fixed finger nearly straight, movable finger slightly curved. Marginal teeth of chelal

fingers subquadrate at the distal end of the row and each tooth with a small cusp on the proximal corner; teeth of the proximal part of each row acuspid and somewhat rounded and flattened; teeth, fig. 17A, regularly spaced along virtually the entire finger margin; each finger with usually between 50 and 60 teeth. Tactile setae of chela arranged as indicated in fig. 17C.

Legs.—Measurements and observations based on two males; whenever the two show a significant difference, the measurement of the holotype is followed in parentheses by the corresponding measurement of a male paratype. Surfaces of segments smooth; setae not abundant except on the distal segments; each coxa II with three (occasionally two) to five irregular and usually serrate spines, these fused at their bases. First leg with pars basalis subcylindrical, slightly deeper across the distal end than elsewhere, 0.192 (0.201) mm. long, 0.053 mm. deep; pars tibialis with weakly convex extensor margin, more convex flexor margin, 0.11 (0.115) mm. long, 0.05 (0.053) mm. deep; tibia subcylindrical, 0.118 (0.128) mm. long, 0.038 (0.041) mm. deep; tarsus tapering a little toward the distal end, 0.2 (0.217) mm. long, 0.034 mm. deep. Fourth leg with pars basalis very stout, 0.145 mm. deep; pars tibialis 0.133 (0.137) mm. deep; entire femur 0.327 (0.345) mm. long; tibia with the distal one-half of the flexor margin markedly convex, 0.247 (0.258) mm. long, 0.068 (0.071) mm. deep; metatarsus with both margins nearly straight, much less deep at the distal than at the proximal end, 0.1 (0.112) mm. long, 0.05 (0.051) mm. deep; metatarsus with a conspicuous pseudotactile seta on the extensor surface not far from the proximal margin; telotarsus subcylindrical, 0.208 (0.205) mm. long, 0.036 (0.035) mm. deep, a pseudotactile seta placed 0.068 (0.07) mm. from the proximal margin.

Genital Complex.—Posterior operculum with about eight marginal setae; 20 to 25 setae superficially placed on each side of the genital opening; about 10 setae on the anterior operculum.

FEMALE.—Unless otherwise indicated, observations and measurements are based on three individuals; measurements given are the limits of range. Like the male in virtually all respects; body length 1.08–1.2 mm.; carapace 0.4–0.43 mm. long, width equal to length; abdomen 0.4–0.55 mm. wide.

Chelicera.—Like that of the male except

the spinneret is better developed, forming a nodule in which gland ducts appear to terminate; serrula exterior of 14 ligulate plates; length of chelicera 0.27–0.31 mm., width of base 0.16–0.185 mm.; movable finger variable, 0.165–0.195 mm. long.

Palp.—Much as in the male but segments possibly a little larger and femur a little stouter. Trochanter 0.152–0.19 mm. long, 0.093–0.11 mm. wide, length 1.63 to 1.73 times the width; femur 0.34–0.395 mm. (allotype 0.372 mm.) long, 0.091–0.102 mm. wide, length 3.7 to 3.93 (allotype 3.93) times width; tibia 0.183–0.22 mm. long, 0.103–0.129 mm. wide, length 1.7 to 1.8 times width; chela 0.55–0.635 mm. (allotype 0.58 mm.) long, 0.125–0.155 mm. wide, length 4.1 to 4.45 (allotype 4.45) times width; chelal hand 0.205–0.24 mm. (allotype 0.217 mm.) long, depth equal to width; movable finger 0.37–0.41 mm. (allotype 0.38 mm.) long. Viewed laterally the shape of hand and fingers, as well as the dentation and chaetotaxy of fingers, essentially as in the male.

Legs.—As in the male; spines of coxa II extremely variable, figs. 17D, 17E. Sometimes longer than width of base (as in the allotype). Measurements given are of two individuals, each measurement of the allotype followed in parentheses by the corresponding measurement of the female paratype. First leg: pars basalis 0.205 (0.216) mm. long, 0.055 (0.061) mm. deep; pars tibialis 0.112 (0.129) mm. long, 0.053 (0.061) mm. deep; tibia 0.129 (0.137) mm. long, 0.04 (0.044) mm. deep; tarsus 0.215 (0.23) mm. long, 0.034 (0.036) mm. deep. Fourth leg: pars basalis 0.14 (0.155) mm. deep; pars tibialis 0.13 (0.137) mm. deep; entire femur 0.354 (0.38) mm. long; tibia 0.263 (0.29) mm. long, 0.069 (0.076) mm. deep; metatarsus 0.114 (0.118) mm. long, 0.052 (0.061) mm. deep; telotarsus 0.225 (0.235) mm. long, 0.036 (0.04) mm. deep; tactile seta located 0.076 (0.08) mm. from proximal margin of the telotarsus.

Genital Complex.—Position of mounted specimens prevents description of the chaetotaxy of the genital complex. However, one female examined in alcohol had 8 to 10 setae on the posterior operculum and 10 setae on the anterior operculum. The genital complex is simple and not sclerotized.

TRITONYMPH.—General appearance as in the male but appendages and body smaller, stouter, and lighter in color; cara-

pac epistome less prominent than in adult; tergal chaetotaxy much as in the adult; body 0.86 mm. long; carapace 0.29 mm. long, greatest width 0.28 mm., ocular and posterior width 0.26 mm.; abdomen 0.56 mm. long, about 0.35 mm. wide.

Chelicera.—Details much as in the adult, but lighter in color, smaller, and stouter; about eight setae in the flagellum; serrula exterior of 12 to 13 plates; length of chelicera 0.21 mm.; length of movable finger 0.133 mm.

Palp.—Measurements of the single available tritonymph as follows: trochanter 0.135 mm. long, 0.084 mm. wide; femur 0.267 mm. long, 0.075 mm. wide; tibia 0.152 mm. long, 0.091 mm. wide; chela 0.43 mm. long, 0.103 mm. wide; chelal hand 0.16 mm. long, 0.103 mm. deep; movable finger 0.29 mm. long. Viewed laterally, fingers somewhat stouter than in male; dorsal margin of hand nearly straight; marginal teeth of same general nature as in male but slightly fewer in number. Movable finger with three setae, difficult to homologize definitely with the setae of the adult; one seta, possibly *t*, located slightly distad from the mid-point of the finger; a second seta, possibly *st*, placed somewhat proximad from the mid-point of the finger and about three areolar diameters from the first seta; *sb* probably wanting; *b* removed from the proximal finger margin by a distance about equal to the width of the finger at the level of the seta. Fixed finger with tactile setae much as in the adult except only one seta on the dorsum of the hand.

Legs.—Segments essentially as in the adult except much smaller and stouter; each coxa II with four or five apparently simple spines, unequal in length. First leg: pars basalis about 0.15 mm. long, 0.049 mm. deep; pars tibialis 0.085 mm. long, 0.045 mm. deep; tibia 0.095 mm. long, 0.037 mm. deep; telotarsus 0.148 mm. long, 0.03 mm. deep. Fourth leg: pars basalis 0.11 mm. deep; pars tibialis 0.102 mm. deep; entire femur 0.258 mm. long; tibia 0.193 mm. long, 0.06 mm. deep; metatarsus 0.08 mm. long, 0.045 mm. deep; telotarsus 0.159 mm. long, 0.038 mm. deep; seta 0.045 mm. from proximal margin of telotarsus.

DEUTONYMPH.—Observations based on one mounted individual. Body and appendages smaller and stouter than in the tritonymph; body not treated with caustic, and chaetotaxy of carapace and tergites not ob-

served; body 0.75 mm. long; carapace nearly 0.24 mm. long, about 0.29 mm. wide, posterior width 0.28 mm., ocular width 0.24 mm.; two weakly developed eyes; abdomen about 0.52 mm. long, 0.3 mm. wide.

Chelicera.—Much like that of the tritonymph; flagellum with about six setae; slightly fewer marginal teeth on fingers and apparently fewer setae on the base; serrula exterior with 10 plates; movable finger 0.102 mm. long.

Palp.—Segments fairly stout; trochanter with the flexor margin irregularly convex, 0.103 mm. long, 0.068 mm. wide; femur distinctly subcylindrical in outline, 0.19 mm. long, 0.059 mm. wide; tibia with extensor margin convex, flexor margin weakly concave, 0.12 mm. long, 0.075 mm. wide; chela 0.325 mm. long, 0.083 mm. wide; chelal hand 0.12 mm. long, 0.08 mm. deep; movable chelal finger 0.215 mm. long. Viewed laterally, fingers appear fairly stout, both a little curved; 30 to 35 teeth on each finger, the teeth of the basal one-third of each finger distinctly rudimentary. Movable finger with two tactile setae, one (possibly *st*) located just within the basal one-third of the finger and the other (possibly *t*) located a little distance proximad from the mid-point of the finger. Fixed finger with setae somewhat as in the tritonymph except *it* and *est* relatively more basal in position, and only two setae (probably *esb* or *eb* wanting) in the group near the base of the finger.

Legs.—Segments much smaller and stouter than in the tritonymph; spines of each coxa II variable, both simple and deeply incised spines present. First leg (measurements subject to possible error as the leg was not dissected from the specimen): pars basalis 0.1 mm. long, 0.036 mm. deep; pars tibialis 0.065 mm. long, 0.036 mm. deep; tibia 0.068 mm. long, 0.034 mm. deep; tarsus about 0.12 mm. long, 0.029 mm. deep. Fourth leg not in a position favorable for measuring.

Holotype, male.—Starved Rock State Park, Illinois: May 6, 1944, M. W. Sanderson.

Allotype, female.—Starved Rock State Park, Illinois: Nov. 8, 1943, mossy debris on shelves. Ross and Sanderson.

Paratypes.—ILLINOIS.—STARVED ROCK STATE PARK: Same data as for holotype, 5♂, 1♀, 1 tritonymph; same data as for allotype, 2♂, 1♀. WHITE PINES FOREST STATE PARK: July 14, 1944, Frison & Sanderson, 2♀, 1 deutonymph, 2 tritonymphs.

The following are additional Illinois records not included in the paratype series: AMBOY: Dec. 6, 1945, Ross & Sanderson, 1 specimen. MOUNT CARROLL: Smith Park, Dec. 6, 1945, 8 specimens. WHITE PINES FOREST STATE PARK: soil cover in oak-hickory grove, Oct. 8, 1933, J. Alsterlund, 1 specimen.

This species occurred in eight collections from the northern one-fourth of the state, all taken from ground cover and debris, especially around sandstone outcroppings. Many of the collections were from Starved Rock State Park and White Pines Forest State Park, where conditions are favorable for the preservation of the original fauna.

Mundochthonius sandersoni new species

This species can be identified by characteristics given in the preceding key and illustrated in fig. 18.

MALE.—Measurements and ratios represent the limits of range of four individuals. Small, fragile, light yellow in color; body and appendages moderately stout; body length 0.75–0.9 mm. Carapace nearly square in dorsal outline; surface virtually smooth except marked on the sides by netlike lines; posterior margin straight, lateral margins usually a little convex; subtriangular epistome with a conspicuously serrate margin; four setae along the posterior carapacic margin; total setae on the carapace probably 20 (difficult to determine in specimens examined); eyes vestigial, often entirely wanting; length of carapace including the epistome 0.28–0.31 mm., greatest width about equal to the length, posterior width slightly less than the greatest width and ranging from 0.27 to 0.31 mm. Abdomen weakly ovate; tergites and sternites not divided; tergites 1, 2, and 3 each with four acuminate setae, more posterior tergites each with six setae; sternites 5 through 11 with 8 to 10 acuminate setae; setae of sternite 4 not determined in the male; length of abdomen 0.5–0.6 mm., width 0.3–0.37 mm. Pleural membranes finely and weakly papillose.

Chelicera.—Large in ratio to the rest of the animal; slightly darker in color than the body and legs; 0.19–0.215 mm. long, width of base 0.115–0.13 mm.; base with six acuminate setae; lateral surfaces of base spinose, spines very short and readily seen only in relief; flagellum of about nine slender plumose setae. Fixed finger curved, apical

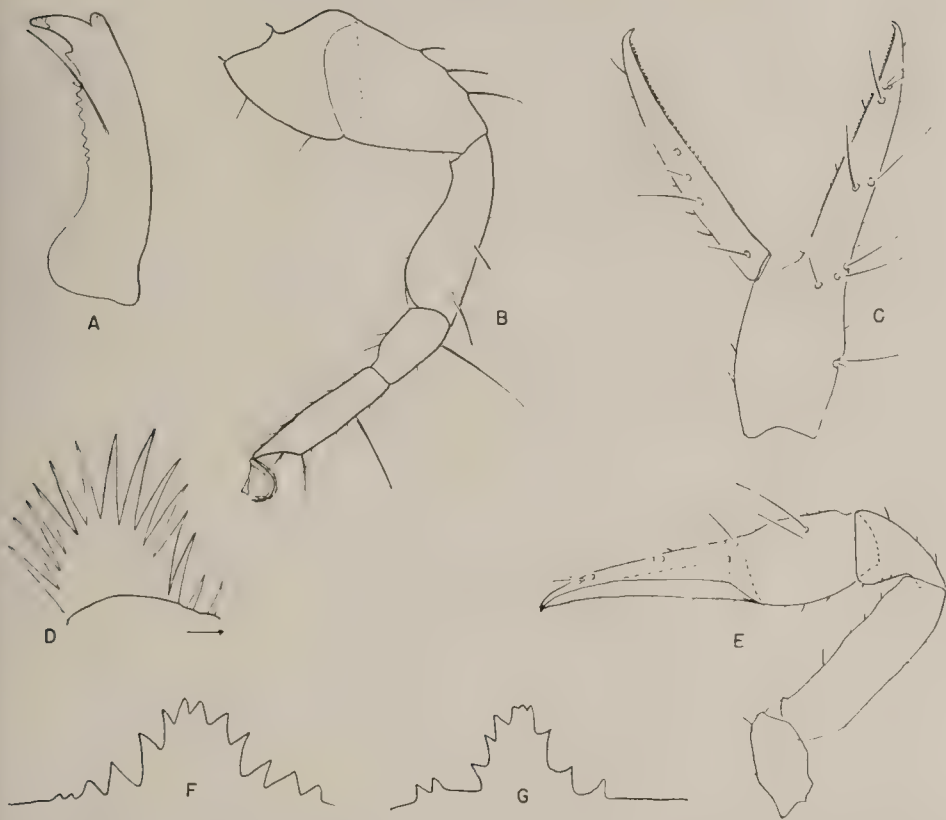


Fig. 18.—*Mundochthonius sandersoni*. *A*, movable cheliceral finger, serrula omitted, paratype, ♀; *B*, fourth leg, paratype, ♀; *C*, lateral view of chela, holotype, ♂; *D*, coxal spines, paratype, ♂; *E*, dorsal view of palp, paratype, ♂; *F*, epistome, paratype, ♀; *G*, epistome, paratype, ♀, another variation.

tooth sclerotized and strong; nearly 12 acute teeth along the internal finger margin, the distal tooth very heavy, teeth toward base weaker; serrula interior reduced: Movable finger 0.1–0.13 mm. long; galeal seta long, inserted near the mid-point of the finger; apical tooth strong and sclerotic; galea represented by a prominent knob, which appears to be the terminus for a few gland ducts; usually between 8 and 10 acute, conical teeth along the distal one-half or two-thirds of the finger margin, with the most distal tooth larger than the others and located some distance from the next more proximal tooth; serrula exterior of 14 to 15 ligulate plates.

Palp.—Fig. 18*E*. Light yellow in color with chela very slightly darker than the rest of the palp; moderately stout; segments with a few acuminate setae; segments smooth except the dorsum of the chelal hand. Trochanter with irregular flexor margin,

usually flatly convex in the central portion; 0.114–0.123 mm. long, 0.064–0.072 mm. wide, length 1.7 to 1.8 times the width. Femur subcylindrical; inner margin slightly concave, outer margin nearly straight in the central portion but convex at each end, widest in the distal half; 0.22–0.25 mm. long, 0.064–0.072 mm. wide, length 3.45 to 3.65 times the width. Tibia subtriangular, widest across the extreme distal end; inner margin weakly concave, outer margin convex, usually a little flatly convex; 0.125–0.15 mm. long, 0.077–0.084 mm. wide, length between 1.63 and 1.73 times the width. Chela with hand moderately stout; fingers slender, strongly but evenly curved in dorsal view; hand with outer margin flatly convex, inner margin more convex; 0.37–0.42 mm. long, 0.091–0.102 mm. wide, length 4.0 to 4.15 times width; hand 0.136–0.152 mm. long, 0.09–0.1 mm. deep; movable finger 0.25–0.285 mm. long, usually 0.27

mm. or more. Viewed laterally, dorsal and ventral margins of the hand weakly convex, fig. 18C, with the arc of the dorsal margin broken by the insertion of the two tactile setae, *ib* and *isb*, on the dorsum of the hand; fixed finger in lateral view with straight inner margin, outer margin weakly convex, finger tapering rapidly in the distal one-fourth; movable finger more slender than the fixed finger. Both fingers usually with from 45 to 55 marginal teeth, varying in structure from the distal ones, which are subquadrate and each with a cusp on the proximal corner, to the proximal ones, which are rounded and acuspid; teeth spaced along most of the finger margin. Tactile setae as in fig. 18C.

Legs.—Moderately stout, light yellow in color; scattered acuminate setae, numerous only on the distal segments. A flat, semi-lunar blade on each coxa II, fig. 18D; the blade irregularly and deeply incised along the margin and showing considerable interspecific variation; blade wider than long; two or three minute short spines often located medially from the blade. First leg with trochanter 0.064–0.075 mm. long, length 1.23 to 1.33 times the depth; pars basalis subcylindrical, deepest near the distal end, 0.118–0.133 mm. long, 0.04–0.045 mm. deep, length 2.9 to 3.05 times the depth; pars tibialis stout, 0.065–0.073 mm. long, length between 1.62 and 1.73 times the depth; tibia with extensor margin nearly straight, flexor margin weakly convex, 0.076–0.087 mm. long, 0.03–0.034 mm. deep, length 2.5 to 2.56 times the depth; tarsus tapering slightly toward distal end, 0.129–0.145 mm. long, 0.025–0.027 mm. deep, length between 4.9 and 5.4 times the depth. Fourth leg with femur stout; chaetotaxy and color much as in the first leg; pars basalis 0.097–0.105 mm. deep; pars tibialis 0.09–0.098 mm. deep; entire femur 0.215–0.24 mm. long, length 2.22 to 2.35 times the depth; tibia with the basal one-third of the extensor margin slightly convex, distal two-thirds of the extensor margin almost straight, flexor margin weakly S-shaped, greatest depth in the distal one-third; 0.158–0.175 mm. long, 0.05–0.055 mm. deep, length 3.15 to 3.3 times the depth; metatarsus stout, a sensory seta near the basal one-fourth of the extensor margin, 0.061–0.072 mm. long, 0.037–0.041 mm. deep, length 1.6 to 1.95 times the depth; telotarsus subcylindrical, margins nearly straight, setae of flexor sur-

face very numerous, 0.122–0.136 mm. long, 0.027–0.3 mm. deep, length 4.47 to 4.54 times the depth; seta of extensor surface of telotarsus removed by 0.03–0.035 mm. from the proximal margin of the segment.

Genital Complex.—Anterior operculum with 10 to 12 scattered setae; posterior operculum with 12 to 16 marginal setae; 8 to 10 setae on the lateral rim of each side of the aperture; setae small and obscure.

FEMALE.—Unless otherwise indicated, measurements are based on seven individuals. Essentially like the male in all details but much larger in actual size of body and appendages, appendages frequently a little stouter. Body length 0.9–1.15 mm.; carapace 0.31–0.33 mm. long, 0.29–0.35 mm. wide; abdomen usually 0.6–0.8 mm. long and 0.3–0.45 mm. wide.

Chelicera.—As in the male; length 0.22–0.245 mm., width of base 0.13–0.15 mm.; movable finger, fig. 18A, between 0.135 and 0.15 mm. long; serrula exterior with 14 ligulate plates.

Palp.—As in the male. Maxilla usually 0.2–0.22 mm. long, about one-half as wide as long; trochanter 0.125–0.135 mm. long, 0.068–0.076 mm. wide, length 1.73 to 1.85 times the width; femur 0.25–0.27 mm. long, 0.072–0.08 mm. wide, length 3.4 to 3.5 times the width; tibia 0.15–0.156 mm. long, 0.09–0.093 mm. wide, length 1.67 to 1.71 times the width; chela 0.42–0.44 mm. long, 0.11–0.18 mm. wide, length 3.68 to 3.89 times the width; chelal hand 0.158–0.168 mm. long, 0.11–0.118 mm. deep, the depth equal to the width; movable finger 0.275–0.295 mm. long.

Legs.—As in the male. Measurements based on four individuals. First leg with trochanter 0.074–0.079 mm. long, length 1.18 to 1.27 times the depth; pars basalis 0.133–0.145 mm. long, 2.95 to 3.05 times the depth; pars tibialis 0.076–0.078 mm. long, length 1.68 to 1.81 times the depth; tibia 0.087–0.095 mm. long, 2.5 to 2.7 times the depth; tarsus 0.132–0.145 mm. long, length 4.35 to 5.4 times the depth, usually under 4.6 times the depth. Fourth leg, fig. 18B, with pars basalis 0.1–0.11 mm. deep; pars tibialis 0.09–0.1 mm. deep; entire femur 0.24–0.25 mm. long, length 2.15 to 2.3 times the depth; tibia 0.17–0.18 mm. long, length 3.1 to 3.25 times the depth; metatarsus 0.072–0.076 mm. long, 1.65 to 1.75 times the depth; telotarsus 0.13–0.14 mm. long, length 4.25 to 4.4 times the depth.

Genital Complex.—Posterior genital operculum with seven or eight acuminate setae; anterior operculum with four setae on each side antiad and laterad to the genital aperture and two additional setae just antiad to the pore.

Holotype, male.—Herod, Illinois: April 18, 1944, Ross & Sanderson.

Allotype, female.—Same data as for holotype.

Paratypes.—Illinois.—Same data as for holotype, 8 ♂, 59 ♀. **HEROD:** ground cover



Fig. 19.—*Microbisium confusum* ♀. An example of the suborder Diplosphyronida and the family Neobisiidae.

in woods, Oct. 12, 1933, Frison & Ross, 1 ♂, 3 ♀. **FOUNTAIN BLUFF:** March 18, 1942, Ross & Sanderson, 1 ♀. **LAKE GLENDALE:** ground cover, March 17, 1943, Ross & Sanderson, 1 ♂, 4 ♀; 1 ♂, 1 ♀ (CH). **LA RUE:** ground cover, April 19, 1944, Ross & Sanderson, 2 ♀ (NHS). **THEBES:** ground cover, April 19, 1944, Ross & Sanderson, 5 ♀.

There are two records in addition to the type series. **DIXON SPRINGS:** March 7, 1945, Ross & Sanderson, 1 specimen. **VIENNA:** debris in woods, Jan. 25, 1947, B. D. Burks, 5 specimens.

This species is dedicated to Dr. Milton W. Sanderson of the Illinois Natural History Survey staff.

UNPLACED SPECIES

6. Genus? *packardi* Hagen

Blothrus packardi Hagen (1879, p. 399).

Chthonius packardi Banks (1895, p. 13).

This species was described from material collected from caves in Kentucky and Indi-

ana. Hagen's description, although insufficient to permit an accurate generic placement, indicates characters that provide means for the separation of this unplaced species from other northeastern species of Chthoniini, as given in the key. The types of this species appear to have been lost, being neither in the U. S. National Museum nor among the types of Hagen's other species at the Museum of Comparative Zoology, and I have seen no material of the species. Since caves occur in Illinois, it is possible that this form may be found in the state.

Suborder DIPLOSPHYRONIDA

In North America, and with rare exception elsewhere, members of this suborder may be recognized by the presence of the divided tarsus of each leg.

KEY TO SUPERFAMILIES

- Movable finger of chelicera toothed along at least one-fifth of inner margin, fig. 25C.
 **Neobisioidea**, p. 443
 Movable finger of chelicera with either a single tooth or with a small group of teeth at apex of inner margin, fig. 27D.
 **Garypoidea**, p. 446

Superfamily NEOBISIOIDEA

Species belonging to this superfamily have the movable finger of the chelicera toothed on the inner margin; the plates of the serula interior are not fused; and the subterminal setae of the pedal telotarsus are seldom simple. A single family, Neobisiidae, is present in our immediate fauna but two other families, Syarinidae and Ideoroncidae, have a very limited number of genera and species in the Rocky Mountain region and in California.

KEY TO FAMILIES

1. Venom apparatus developed in both fixed and movable chelal fingers.
 **Ideoroncidae**
 Venom apparatus developed only in the fixed finger, fig. 24 2
2. Pleural membrane of abdomen smoothly and longitudinally plicate, never granulate; suture between pars basalis and pars tibialis of femur IV at least slightly oblique to the long axis of the femur.
 **Syarinidae**
 Pleural membrane of abdomen granulate or granulo-striate; suture between parts

of femur IV truly perpendicular to the long axis of the femur. . . . **Neobisiidae**

IDEORONCIDAE

The genus *Albiorix* Chamberlin is reported from the southwestern part of the United States. A key to the species of the genus is given by Hoff (1945e).

SYARINIDAE

This family is represented in the American fauna north of Mexico by one genus, *Syarinus* Chamberlin, with a limited number of species in the Rocky Mountain and Pacific Coast areas and by two very restricted genera, *Hyarinus* Chamberlin and *Chitra* Chamberlin, in California.

NEOBISIIDAE

Members of this family are identified by the presence of a venom apparatus only in the fixed finger, by the granulate nature of the pleural membranes, and by the vertical suture between the pars basalis and pars tibialis of the third and fourth legs. One subfamily is represented in Illinois, and a second is known from Arkansas.

KEY TO SUBFAMILIES

- Cheliceral galea present, at least almost as long as the apical tooth and having one or more branched processes, fig. 23. **Ideobisiinae**
- Cheliceral galea wanting or represented by no more than a sclerotic knob, fig. 25C. **Neobisiinae**

Subfamily IDEOBISIINAE

While this subfamily has not been reported from Illinois, it is possible that, with further collecting, members of the genus *Microcrea-gris* may be found in the state.

7. MICROCREAGRIS Balzan

Microcrea-gris Balzan (1891, p. 543). Genotype, monobasic: *Microcrea-gris gigas* Balzan.

This genus, figs. 22, 23, may be separated from the other genera of the subfamily by the way in which the tactile setae *t*, *st*, and *sb* are scattered on the movable chelal finger rather than clustered submedially. There is a single simple or branched galea.

This genus is not reported from Illinois,

but *ozarkensis* Hoff (1945a) has been described from Arkansas; and it is expected that this or related species of *Microcrea-gris* may eventually be found in Illinois.

Subfamily NEOBISIINAE

This subfamily forms a coherent group of forms in which the galea is either wanting or greatly reduced and represented by no more than a sclerotic knob. A single genus is recorded from Illinois. A second genus, *Neobisium* Chamberlin, is included here since it has been reported from Tennessee.

KEY TO GENERA

- Four long tactile setae present on movable chelal finger and eight on fixed chelal finger, fig. 20. **8. Neobisium**
- Three long tactile setae present on movable, and seven on fixed, chelal finger, fig. 25B. **9. Microbisium**

8. NEOBISIUM Chamberlin

Neobisium Chamberlin (1930, p. 11). Genotype, by original designation: *Obisium muscorum* Leach.

The genus, figs. 20, 21, can be recognized by the character given in the key, by the presence of tactile setae *et*, *est*, and *it* on the distal third rather than the distal fourth or fifth of the fixed chelal finger, and by the no more than moderately slender legs and palp.

To date this genus has not been reported from Illinois but is represented by several species occurring in the southeastern states. One of these, *tenuis* Chamberlin, has been taken in Tennessee and there is a possibility that it or one of its congeners may ultimately be found in Illinois.

Chamberlin (1930) described *tenuis* as a variety of *carolinensis* (Banks 1895). On the basis of differences pointed out by Chamberlin in the original description of *tenuis*, it seems probable that this form should have specific rather than varietal status. The typical form of *carolinensis* is found in Georgia and North Carolina, while *tenuis* is confined to the mountain area of eastern Tennessee. Because of its habitat, *tenuis* is hardly to be expected in our fauna.

9. MICROBISIUM Chamberlin

Microbisium Chamberlin (1930, pp. 10, 20).

Genotype, by original designation: *Obisium brunneum* Hagen.

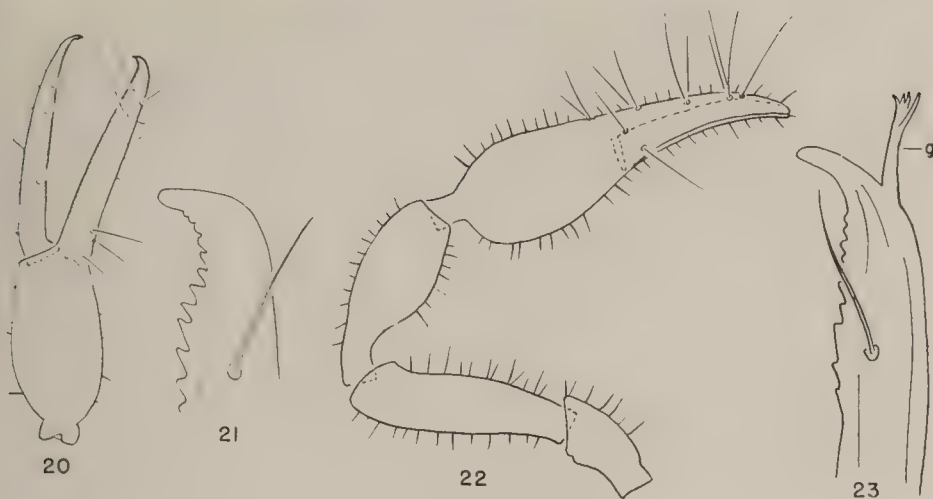


Fig. 20.—*Neobisium carolinensis tenuis* ♂. Lateral view of chela.

Fig. 21.—*Neobisium carolinensis tenuis* ♂. Distal part of movable cheliceral finger.

Fig. 22.—*Microcreagris ozarkensis* ♂. Dorsal view of palp.

Fig. 23.—*Microcreagris ozarkensis* ♂. Distal half of movable cheliceral finger; *g*, galea.

Members of this genus are peculiar in that the number of tactile setae of the chelal fingers is reduced to three setae on the movable finger and seven setae on the fixed finger, fig. 25B. Males have not been found in this genus.

Three species are placed in the genus, two eastern ones treated below, and a third, *parvulum* (Banks), from the southwestern states. These are treated by Hoff (1946e).

KEY TO SPECIES

- Palpal femur less than 0.4 mm. long, length between 2.42 and 2.89 times the width....
confusum
 Palpal femur more than 0.4 mm. long, length between 2.87 and 3.2 times the width
brunneum

Microbisium brunneum (Hagen)

Obisium brunneum Hagen (1869, p. 52).

Microbisium brunneum (Hagen). Chamberlin (1930, p. 20), Hoff 1946e, p. 494.

Microbisium brunneum (Hagen), in part. Hoff (1944a, p. 125; 1946b; p. 109).

This species is readily identified by characters indicated in the key. An extensive re-description of the species is given by Hoff (1946e).

DISTRIBUTION.—*Microbisium brunneum* has a wide geographic range in eastern Canada and in northern United States from New York to Illinois. In Illinois its distribution is markedly discontinuous. It has

been taken in 14 collections from Lake County in the northeastern corner of the state and in 1 collection each from Alexander and Pulaski counties, both in the extreme southern tip of the state. All collections of this species from Lake County were made from tamarack bogs. Of the collections from the southern tip of the state, one was taken from "dry forest" in the Horseshoe Lake Game Refuge near Olive Branch and the other was from "humus and soil from drier part of bank, cypress bottoms" near Karnak. The distribution seems to indicate that *brunneum* is associated with acid soil and water and with deciduous coniferous trees in Illinois associated with either tamarack or cypress.

Illinois Records.—About 200 adults and nymphs of all sizes from several localities. **ANTIOCH:** sphagnum moss in tamarack bog, Oct. 15, 1942, and Oct. 27, 1943, Ross & Sanderson. **KARNAK:** humus and soil from drier part of bank, cypress bottoms, Feb. 24, 1933, Ross & Mohr. **OLIVE BRANCH:** Horseshoe Lake Game Refuge, dry forest, Dec. 2, 1943, Frison & Ayars. **VOLO:** sphagnum moss in tamarack bog, Oct. 7, 1933, J. Alsterlund; sphagnum moss in tamarack bog, Oct. 27, 1943, Ross & Sanderson. **WAUCONDA:** ground cover in tamarack bog, March 16, 1933, Frison & Mohr; tamarack bog, ground cover, Oct. 20, 1943, Ross & Sanderson.

Microbisium confusum Hoff

Microbisium brunneum Hoff (*non* Hagen), in part (1944a, p. 125; 1946b, p. 109). Misidentification.

Microbisium confusum Hoff (1946e, p. 496).

Identification of this species can be made by the characteristics given in the key and illustrated in figs. 19, 25A, 25B. In addition to the scheme indicated in the key, the following will help in separating *brunneum* and *confusum*. *M. confusum* shows the following average differences when compared with *brunneum*: the body is smaller; the palp is smaller, less sclerotized, less deeply colored, and less polished; the palpal femur is conspicuously smaller and stouter; the pedicle of the tibia is commonly less slender and the inner margin of the palpal tibia is usually more evenly rounded or convex; and the chelal fingers appear stouter when viewed from the dorsum. Additional descriptive material is contained in the original description (Hoff 1946e).

DISTRIBUTION.—*Microbisium confusum* appears to be the common species of the genus in the Mississippi River valley and the eastern United States. In Illinois it is the most widely distributed and most abundant species of all the pseudoscorpions and has been taken in 148 collections from all parts of the state. It occurs in forest soil and litter, and in decayed logs or stumps. The species is found associated with *brunneum* in the tamarack bogs of northeastern Illinois.

Illinois Records.—Many adults and nymphs taken during all months of the year

are from Adams County, Alhambra, Alto Pass, Antioch, Apple River Canyon State Park, Astoria, Aurora, Bensenville, Brownfield Woods, Browning, Burksville, Burton, Cadiz, Caledonia, Charleston, Clarksville, Collinsville, Cook County, Danville, Dixon Springs, Dolson, Elgin, Enfield, Fountain Bluff, Fox Ridge State Park, Freeport, Galena, Geff, Giant City State Park, Grafton, Halfday, Havana, Herod, Highland Lake (near Grays Lake), Ivanhoe, Kampsville, Kell, Kellerville, La Grange, Lake Glendale, Lake Zurich, La Rue, Lincoln, Logan, Magnolia, Makanda, Marshall, Mascoutah, Mason County, Monticello, Mound City, New Windsor, Oakwood, Palestine, Palisades State Park, Paloma, Palos Park, Peoria, Pocahontas, Quincy, Ruma, Seymour, Sherman, Siloam, (Siloam Springs), Starved Rock State Park, Summit, Troy, Urbana, Ursa, Vienna, Volo, Wauconda, Waukegan, White Pines Forest State Park, Winthrop Harbor, Zion.

Superfamily GARYPOIDEA

Members of this superfamily are characterized as follows: the movable cheliceral finger, instead of being toothed on the inner margin, bears a simple, or occasionally a subdivided, subterminal lobe; the plates of the serrula interior are fused basally to form a velum and only the terminal teeth are free; the subterminal setae of the telotarsi are always simple and acute. Three families are represented in the United States but only one, the Garypidae, has representatives in the north-central part of the country.

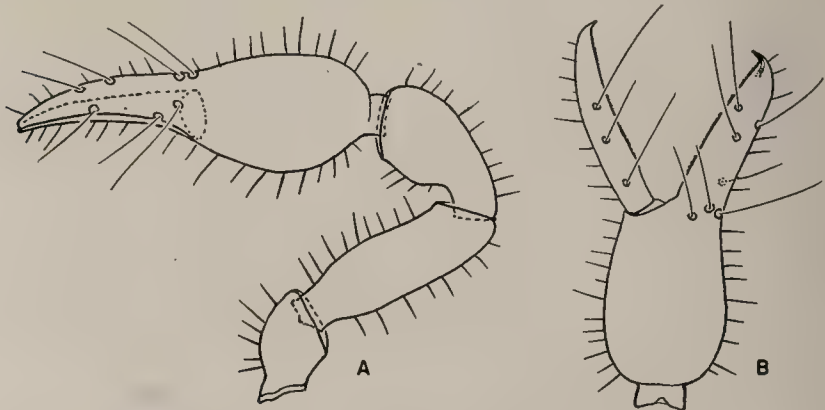


Fig. 24.—*Microbisium brunneum* ♀. A, dorsal view of palp; B, lateral view of chela, poison gland (in fixed finger only) shown by dotted line.

KEY TO FAMILIES

1. Venom apparatus developed in fixed finger only; at base of reduced or vestigial apical tooth of the movable finger is a groove, the receptor venedentis, into which fits the tooth or venedens of the fixed finger. **Menthidae**

Venom apparatus developed in both fixed and movable fingers; movable finger without receptor venedentis. 2

2. Pleural membrane smoothly and evenly plicate; carapace usually not triangular; coxal area never widened posteriorly; setae of palpal femur and tibia conspicuous, always slender and acute. **Olpiidae**

Pleural membrane not smoothly and evenly plicate; carapace definitely triangular in shape, fig. 27C; coxal area with few exceptions much widened posteriorly; setae of the palpal femur and tibia short and inconspicuous; if acute, these setae are very short. **Garypidae**

MENTHIDAE

This family is represented in America north of Mexico by a single genus, *Menthus* Chamberlin, a few species of which occur in California.

OLPIIDAE

The family contains a few genera and species confined in the United States chiefly to the arid and semiarid regions of the Southwest.

GARYPIDAE

This family is characterized by a venom apparatus in each of the chelal fingers; investing setae of palpal femur and tibia short and inconspicuous; pleural membranes granular or with rugose striations, not evenly striated; carapace subtriangular; abdomen broader than the cephalothorax. A single genus occurs in central and eastern United States. The only other nearctic genus, *Garypus*, is represented by a few species in California and doubtful records from Florida.

10. **LARCA** Chamberlin

Larca Chamberlin (1930, p. 609). Genotype, by original designation: *Garypus latus* Hansen.

This genus, fig. 26, contains species in which the arolia are longer than the terminal

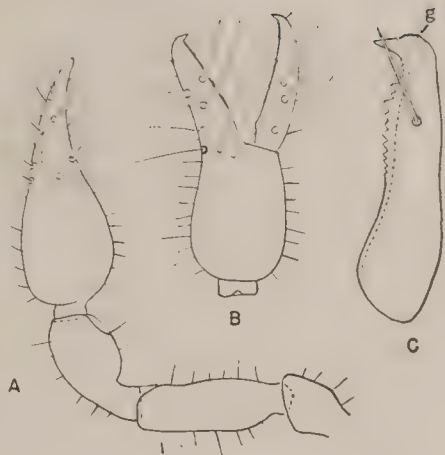


Fig. 25.—*Microbisium confusum* ♀. A, dorsal view of palp; B, lateral view of chela; C, chelicera, movable finger; g, knoblike galea, showing silk ducts. A and B same scale as fig. 24.

claws of the pedal tarsi; the movable chelal finger has two tactile setae; pars basalis of legs I and II is never much longer than the pars tibialis; the femoral articulation of the first two pairs of legs is only slightly mobile; the investing setae of the palps are decidedly lanceolate. Only the following species of this genus is known to occur in North America.

Larca granulata (Banks)

Garypus granulatus Banks (1891, p. 163).



Fig. 26.—*Larca granulata*. An example of the suborder Diplosphyronida and the family Garypidae. The division of the tarsus into metatarsus and telotarsus is so obscure and weak that it is not discernible in the figure.

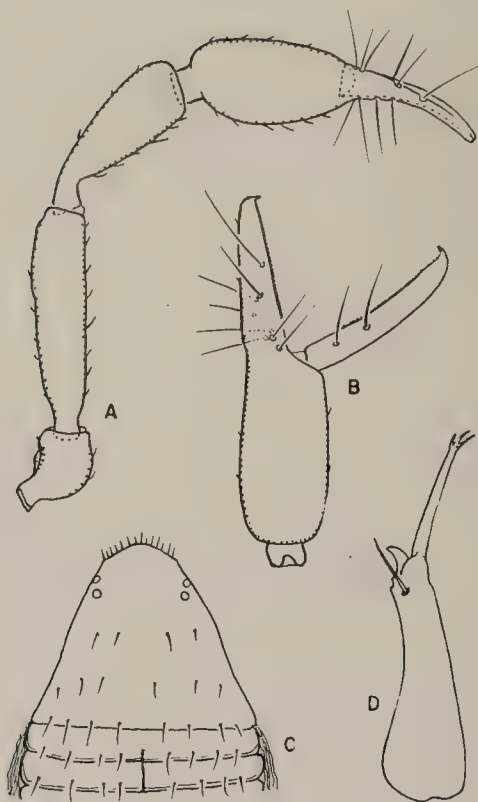


Fig. 27.—*Larca granulata* ♀. A, dorsal view of palp; B, lateral view of chela; C, dorsal view of carapace; D, chelicera, movable finger.

Larca granulata (Banks). Chamberlin (1930, p. 616), Hoff (1946b, p. 109).

Chernes dentatus Ross (*non* Banks), (1944, fig. 56). Misidentification.

Individuals of this species are easily recognized by the family characteristics, since this is the only garypid pseudoscorpion in the state. For sight recognition, the following characters are useful: the stout abdomen in which the width is nearly equal to the length, the triangular carapace, and the slender form of the palpal segments, fig. 27A.

The following measurements are given for a more detailed check of identifications. They were taken from a female mounted in Canada balsam: body length 2.1 mm.; carapace 0.6 mm. long, 0.8 mm. wide across the posterior margin; abdomen 1.5 mm. long, 1.3 mm. wide; palpal trochanter 0.3 mm. long, 0.17 mm. wide; femur 0.66 mm. long, 0.163 mm. wide; tibia 0.57 mm. long,

0.185 mm. wide; chela exclusive of pedicle 0.85 mm. long, 0.247 mm. wide; depth of chelal hand 0.215 mm., length 0.44 mm.; movable chelal finger 0.44 mm. long. First leg with pars basalis 0.235 mm. long, 0.09 mm. deep; pars tibialis 0.175 mm. long, 0.103 mm. deep; tibia 0.215 mm. long, 0.075 mm. deep; metatarsus 0.15 mm. long, 0.055 mm. deep; telotarsus 0.14 mm. long, 0.045 mm. deep. Fourth leg with entire femur 0.49 mm. long, 0.133 mm. deep; tibia 0.37 mm. long, 0.088 mm. deep; metatarsus 0.18 mm. long, 0.065 mm. deep; telotarsus 0.175 mm. long, 0.05 mm. deep.

In the Illinois collections are several nymphs of two sizes. Since the determination of which nymphal stages are represented is questionable, it is desirable to wait for descriptions until all three nymphal stages are available for study.

DISTRIBUTION.—This species occurs in the central and northeastern United States. No collections have been taken in Illinois in addition to those previously recorded (Hoff 1946b) from Starved Rock State Park (La Salle County) and Fountain Bluff (Jackson County).

The species is found chiefly in debris and moss on sandstone ledges.

Illinois Records.—**FOUNTAIN BLUFF:** March 18, 1942, Ross & Sanderson, 3 adults. **STARVED ROCK STATE PARK:** mossy debris on shelves, sandstone bluff, Nov. 8, 1943, Ross & Sanderson, 5 adults, 4 nymphs.

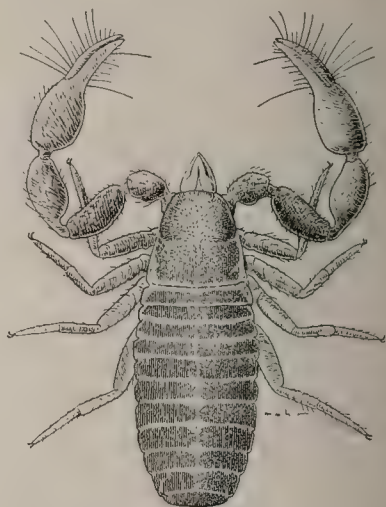


Fig. 28.—*Pselaphochernes parvus*. An example of the suborder Monosphyronida and the family Chernetidae.

Suborder MONOSPHYRONIDA

Pseudoscorpions of this suborder have only a single tarsal segment on each leg. Three superfamilies are recorded from America north of Mexico, only one of which is represented in the north-central part of the United States.

KEY TO SUPERFAMILIES

1. With four prominent eyes....**Feaelloidea**
With two eyes or none, never with four...2
2. Femora of legs I and II similar to those of legs III and IV, with the same type of articulation.....**Cheiridioidea**
Femora of legs I and II each with a more or less distinct membranous articulation between pars basalis and pars tibialis, the apex of the pars basalis often enlarged, and the less deep base of the pars tibialis frequently appears to fit into it, fig. 44*A*; femora of legs III and IV with pars basalis and tibialis more or less fused solidly, about the same length where they join, the fusion being a somewhat straight suture, fig. 44*B*...
.....**Cheliferoidea**

Superfamily FEAELLOIDEA

The nearctic fauna of this superfamily contains only the family Pseudogarypidae, represented in North America by a single genus, *Pseudogarypus* Ellingsen. This genus has only a few species and is restricted to the Rocky Mountain and the Pacific Coast areas.

Superfamily CHEIRIDIOIDEA

Two families are represented in the fauna of America north of Mexico, but neither is found in Illinois.

KEY TO FAMILIES

- Venom apparatus developed only in fixed chelal finger; femoral articulations of legs lacking or vestigial so that the pars tibialis and the pars basalis appear to be fused into one....
.....**Cheiridiidae**
- Venom apparatus developed in both chelal fingers; femoral articulations of legs well developed.....**Sternophoridae**

CHEIRIDIIDAE

This family is represented in America north of Mexico by a few species of the genus *Apocheiridium* Chamberlin, found only on the west coast of the United States.

STERNOPHORIDAE

Representatives of this family are found in western Mexico, southern United States, and Australia (Chamberlin 1931*a*). Two genera, one of which is of uncertain status, have been placed in the family. A limited number of species of the genus *Sternophorus* Chamberlin are known from southern and southwestern United States and one species of the genus *Garyops* Banks has been reported from Florida. The genus *Garyops* is inadequately described and *Sternophorus* may eventually prove to be a synonym.

Superfamily CHELIFEROIDEA

Members of this superfamily always have the femora of the first and fourth legs structurally dissimilar; eyes two or none. The group is represented in America north of Mexico by three families, two of which have representatives in our area.

KEY TO FAMILIES

1. At least a few accessory teeth present on chelal fingers, figs. 32*D*, 34*B*, 36*A*; venom apparatus well developed in movable finger only, but may be present as a vestige in the fixed finger.....
.....**Chernetidae**, p. 449
No accessory teeth present on chelal fingers, figs. 49*C*, 50*C*, 51*C*; venom apparatus not as above.....2
2. Venom apparatus developed in fixed finger only; terminal venom tooth of fixed finger structurally much more prominent than terminal tooth of movable finger.....**Atemnidae**, p. 485
Venom apparatus developed equally well in both fixed and movable fingers, fig. 51*C*; terminal teeth of both fingers equal in size, or nearly so.....
.....**Cheliferidae**, p. 485

CHERNETIDAE

Both nearctic subfamilies of this family are known from Illinois. In use of the following key for their separation, great care must be exercised because the tactile seta of the fourth pedal tarsus is often broken or lost.

KEY TO SUBFAMILIES

- Setae of body and palps long and acuminate; when present, the tactile seta of the fourth pedal tarsus is located considerably proximad

from the mid-point of the segment.

..... **Lamprochernetinae**
At least some of the setae of body and palps
denticulate, well feathered, or plumose, often
appearing club shaped, figs. 36*A*, 37*D*, 46;
when present, the tactile seta of the fourth
pedal tarsus is located near the middle or
distad from the middle of the segment.

..... **Chernetinae**

Subfamily LAMPROCHERNETINAE

This subfamily is characterized by a straight or slightly convex posterior carapacic margin; the setae on the body and palps are long and acuminate; and, when present, the tactile seta of the tarsus of the fourth leg is inserted near the base of the tarsus. Only two genera are recorded from America north of Mexico. One genus, *Lamprochernes* Tömösváry, is found in the eastern and central parts of the United States. From California and Florida is reported the other genus, *Lustrochernes* Beier, which contains chiefly species that are of uncertain position because of inadequate descriptions.

11. *LAMPROCHERNES* Tömösváry

Lamprochernes Tömösváry (1882, p. 185).

Genotype by subsequent designation of Beier (1932*c*, p. 82): *Chelififer nodosus* Schrank.

Lamprochernes Tömösváry. Beier (1932*c*, p. 82).

The genus *Lamprochernes* is characterized by the absence of an accessory tooth on the tarsal claws of the legs and by the position of the tactile setae of the fixed chelal finger, it always being clearly farther from the finger tip than *ist* is from *isb*. Four nearctic species are known: *ellipticus* Hoff (1944*b*) from Mexico, *grossus* (Banks) from Colorado, and the two following.

KEY TO SPECIES

Hand of chela subquadrate in dorsal view,
subtruncate at base, fig. 30*A*; chela exclusive
of pedicle usually less than 0.8 mm. long,
length 2.4 to 2.6 times the width. ***oblongus***
Hand of chela subovate, basal margin some-
what rounded, fig. 29*A*; chela exclusive of
pedicle more than 0.8 mm. long, length 2.8
to 3.0 times the width. ***minor***

Lamprochernes oblongus (Say)

Chelififer oblongus Say (1821, p. 64).

Chelififer (*Lamprochernes*) *oblongus* (Say).
Ellingsen (1909, p. 368).

Chelanops oblongus (Say). Ewing (1911, p. 79).

Lamprochernes oblongus (Say). Beier (1932*c*, p. 84).

Since the type specimens deposited by Say in the Philadelphia Academy have apparently been lost, a neotype has been selected and deposited in the collection of the Illinois State Natural History Survey. A detailed description is given here of *oblongus* because no description is available in the literature except the very brief diagnosis given by Beier (1932*c*). Beier's diagnosis is possibly based on specimens from Pennsylvania reported by Ellingsen (1909) as being deposited in the Berlin Museum. Illinois specimens of this species agree well with Beier's description except that our specimens usually have slightly more slender chelae. This difference was noticed also in specimens from Arkansas and Georgia as previously reported (Hoff 1945*a*).

Ewing (1911) reported material from Marshall, Champaign, and Muncie, Illinois, under the name *Chelanops oblongus*. His material from Marshall, deposited in the Museum of Comparative Zoology, has been re-examined, but his specimens from the other localities were not available for study.

MALE.—The following measurements and ratios are based on three males, including the neotype. Body slender and elongate; light brown in color with palps a deeper reddish-brown; length of body 1.75–2.1 mm. Carapace widest near the middle, a little narrower across the posterior margin; 8 or 10 setae along the posterior carapacic margin; two transverse furrows, the median one deeper than the posterior one; weak eye spots, hardly discernible in specimens treated in caustic; surface of carapace almost smooth; length of carapace 0.6–0.65 mm., greatest breadth 0.45–0.53 mm., posterior breadth 0.45–0.53 mm., ocular width usually about 0.32 mm. Abdomen subcylindrical, slender; tergites, except the first two to four and the eleventh, well divided; surface with very weakly developed scalelike sculpturing; tergal chaetotaxy ranging from about 10 setae on tergite I to as many as 8 or 10 setae on each tergal half in the central and posterior part of the abdomen. Sternites, except XI, weakly divided; usually eight or nine setae in each sternal half but only three or four marginal setae on each half of sternite IV; sternites with color and sculpturing much as on the ter-

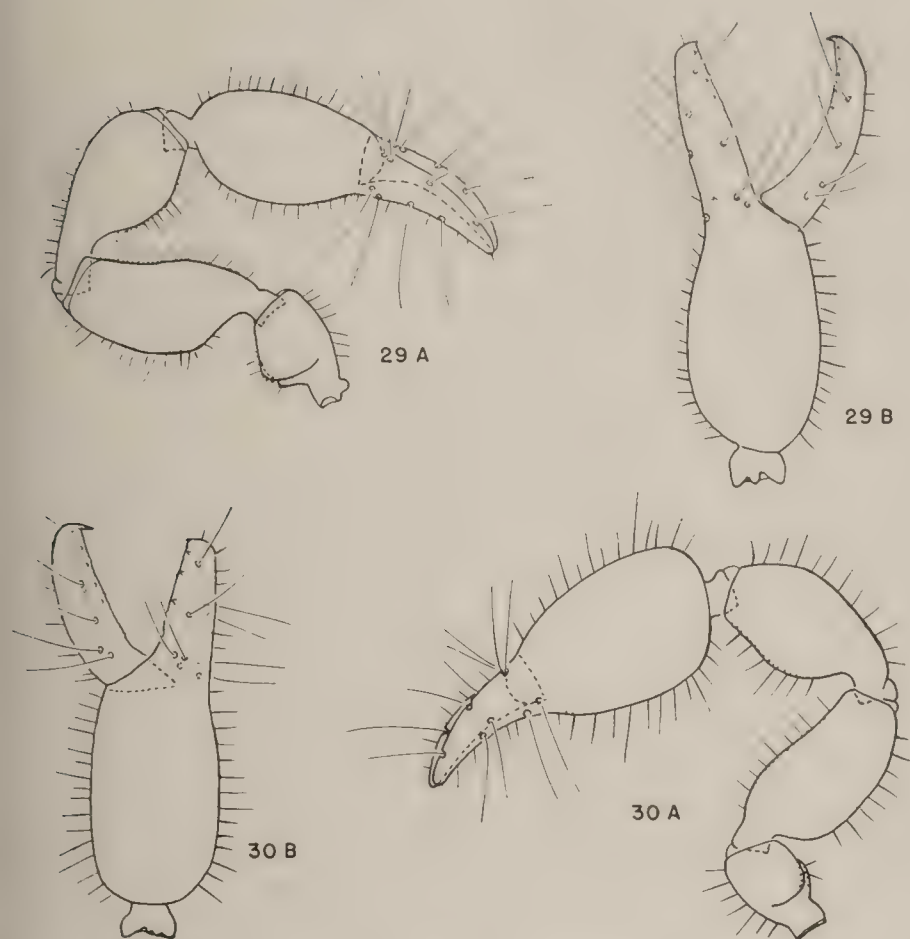


Fig. 29.—*Lamprochernes minor*, holotype ♂. A, dorsal view of palp; B, lateral view of chela.

Fig. 30.—*Lamprochernes oblongus*, neotype ♂. A, dorsal view of palp; B, lateral view of chela.

ites; each stigmatic plate with three setae; abdomen 1.2–1.5 mm. long, 0.5–0.7 mm. wide.

Chelicera.—Fig. 8. Yellow in color; fingers relatively slender; flagellum of three setae, of which the one farthest anteriorly is unilaterally serrate along the distal one-half; basal and subbasal setae relatively short, each with a few very minute, subterminal denticulations; hand of chelicera with netlike sculpturing on the anterior or dorsal aspect; length of chelicera 0.17–0.19 mm., width of base 0.1–0.11 mm. Fixed finger slender; inner aspect of apical tooth with three denticles; inner finger margin with four or five teeth, of which the two

or three basal ones are very weakly developed; serrula interior with the four distal plates free. Movable finger straight; subapical lobe stout, well developed, and located very close to the base of the apical tooth; apical tooth with a tendency to form two or three poorly developed terminal cusps; galeal seta not reaching to the tip of the galea; galea long, slender, usually with six simple rami in the distal one-half; serrula exterior of 17 to 18 ligulate plates; length of movable finger 0.145–0.16 mm.

Palp.—Fig. 30A. Stout, usually deep reddish-brown in color, occasionally lighter; setae fairly numerous, long, appearing acuminate but usually with one to a few

minute, subterminal spinules; surface of segments smooth except for minute granules on the flexor surface of the femur, on the flexor surface and the protuberances of the trochanter, on the flexor surface of the tibia, and usually on the inner surface of the chelal hand near the finger base. Maxilla with ventral face subtriangular in outline; length about 0.3 mm. Trochanter with both sublateral and subdorsal protuberances little elevated; length of trochanter 0.27–0.31 mm., 1.8 to 1.9 times the width in strict dorsal view. Femur with pedicle a little wider than long, well separated from the rest of the segment; flexor margin S-shaped, extensor margin flatly convex in the central portion; length measured along the extensor margin 0.41–0.45 mm., 2.0 to 2.1 times the maximum width; over-all or greatest length 0.45–0.48 mm., 2.2 to 2.3 times the width; width between 0.195 and 0.215 mm. Tibia with a pedicle about as long as wide; tibia much swollen and globose beyond the pedicle; length 0.415–0.465 mm., width 0.21–0.24 mm., length 1.9 to 2.0 times the width. Chela viewed from dorsum with hand heavy and somewhat subquadrate; fingers stout and a little curved; hand basally subtruncate; length of chela without pedicle 0.69–0.77 mm., width 0.27–0.315 mm., length 2.4 to 2.6 times the width; chelal hand without the pedicle 0.4–0.43 mm. long, depth usually less than the width and between 0.24 and 0.31 mm.; movable chelal finger 0.3–0.36 mm. long. Viewed laterally, fig. 30B, chelal hand subquadrate, dorsal and ventral margins weakly convex, basal margin well rounded and not subtruncate; fingers stout; the fixed finger nearly straight, the movable finger slightly curved; movable finger conspicuously shorter than the hand without the pedicle. Marginal teeth of fingers cuspid, conical, and contiguous; usually 25 to 30 teeth on each finger; in most specimens, from 2 to 4 (rarely only 1) accessory teeth in each row, with the greater number in the external row of each finger. Tactile setae arranged as in fig. 30B.

Legs.—Yellow in color, often with an orange tinge; segments stout; surface often marked by netlike or scalelike markings. First leg with trochanter 0.1–0.12 mm. long, length 1.1 to 1.25 times the depth; pars basalis 0.1–0.11 mm. deep; pars tibialis 0.105–0.125 mm. deep, both margins evenly convex; entire femur 0.3–0.35 mm. long, 2.7 to 2.9 times the depth; tibia weakly

S-shaped, 0.23–0.26 mm. long, 0.075–0.085 mm. deep, length 3.0 to 3.1 times the depth; tarsus subcylindrical in outline, about 0.2 mm. long, 0.05–0.055 mm. deep. Fourth leg with both margins of the femur evenly and weakly convex, 0.41–0.47 mm. long, 0.145–0.167 mm. deep, length 2.7 to 2.8 times the depth; tibia 0.31–0.355 mm. long, length 3.3 times the depth; tarsus subcylindrical, 0.23–0.27 mm. long, 0.06–0.068 mm. deep, length 3.7 to 4.0 times the depth; tactile seta of the tarsus removed from proximal margin by 0.06–0.08 mm.

Genital Complex.—Posterior operculum with 8 to 10 setae arranged chiefly in a row along the margin and with 4 to 6 setae on the posterior rim of the aperture. Anterior operculum with 18 to 24 scattered setae.

FEMALE.—Measurements and ratios based on three individuals. Almost identical in detail with the male; body length 2.35–2.5 mm.; carapace 0.62–0.68 mm. long, 0.49–0.53 mm. wide; abdomen 1.7–1.85 mm. long, 0.75–0.9 mm. wide.

Chelicera.—No sexual dimorphism exhibited; length of chelicera 0.185–0.2 mm., base 0.105–0.115 mm. wide; movable finger 0.155–0.17 mm. long.

Palp.—In general as in male; trochanter 0.3–0.31 mm. long, about 0.17 mm. wide; femur with extensor margin 0.43–0.45 mm. long, greatest length 0.475–0.5 mm., width 0.2–0.22 mm.; tibia 0.45–0.48 mm. long, 0.23–0.24 mm. wide; chela without pedicle 0.75–0.8 mm. long, 0.3–0.305 mm. wide; chelal hand without pedicle 0.42–0.44 mm. long, 0.25–0.28 mm. deep; movable finger 0.35–0.38 mm. long.

Legs.—As in the male. First leg with entire femur 0.33–0.355 mm. long, 0.12 mm. deep across the pars tibialis; tibia 0.25–0.26 mm. long, 0.08–0.085 mm. deep; tarsus 0.205–0.235 mm. long, 0.055–0.057 mm. deep. Fourth leg with entire femur 0.45–0.48 mm. long, depth across the pars tibialis 0.165–0.168 mm.; tibia 0.335–0.355 mm. long, 0.1–0.105 mm. deep; tarsus 0.24–0.275 mm. long, 0.065–0.072 mm. deep; tactile seta of tarsus between 0.055 and 0.075 mm. from the proximal margin.

Genital Complex.—Usually 8 to 10 setae in a marginal row along the posterior operculum; anterior operculum with 6 to 8 setae posteriad to a compact median group of 10 to 14 setae.

Neotype, male.—Havana, Illinois, duff in forest, Nov. 9, 1943, Ross & Sanderson.

DISTRIBUTION.—This species is widespread east of the Great Plains area. In all 4 collections of *oblongus* have been identified from scattered localities over Illinois. Almost invariably, this species is taken from under the bark of oak logs and stumps, as indicated both by Ewing's collections and by the present series. Rarely the species is taken from woody debris and even more rarely from ground cover.

Illinois Records.—ASTORIA: under oak bark, Nov. 1, 1943, Ross & Sanderson, 6 ♀, ♂, 2 nymphs. AURORA: Sept. 4, 1939, H. Wybas, 1 ♀ (JC). BENTON: May 31, 1945, J. Whitlow, 7 specimens. ELSAH: May, 1946, C. L. Remington, 2 ♂ (CR). GRAND FLOWER: under bark of log, March 18, 1943, Ross & Sanderson, 3 ♀. HAVANA: ground cover in forest, Nov. 9, 1943, Ross & Sanderson, 2 ♂. LYONS (Cook County): Bemis Woods, under bark of oak log, June 27, 1944, C. L. Remington, 1 ♀. MARSHALL: under bark of log, Feb. 6, 1909, H. E. Ewing, 1 specimen (MCZ). QUINCY: Coe's Spring, bark removed from old log suspended over stream, Jan. 4, 1943, C. C. Hoff, 1 nymph; south of St. Anthony's Church, under bark of old snag in pasture, July 8, 1944, C. C. Hoff, 1 nymph, 1 ♀ (CH). SILOAM: Siloam Springs, under bark of log, Oct. 8, 1945, C. C. Hoff, 1 ♀ (CH). URBANA: Dodson's Woods, under bark of fallen white oak, June 6, 1927, Miller, 1 ♀ (JC). ZEIGLER: Oct. 11, 1933, Frison & Ross, 1 ♂.

Lamprochernes minor new species

This species, figs. 29A, 29B, is readily separated from *oblongus* by the shape of the palpal chela. In many respects, this new species shows much closer affinity to European and North African species than it does to *oblongus*. The closest relationship appears to be with *nodosus* (Schrank) and *chyzeri* Komösváry. From these two forms, *minor* may be separated by the more granular carapace and differences in the shape of the palpal femur.

MALE.—Description based on the male holotype. Body slender, legs moderately stout, palps stout; body and legs light brown in color, the palps deeper brown; length of body 2.18 mm. Carapace rounded anteriorly, sides somewhat convex, widest near the center; two well-marked, transverse furrows, the posterior one very little closer to the posterior carapacic margin than to the median furrow; no eye spots observed; about

10 setae along the posterior carapacic margin; carapace moderately granular except on the dorsal surface anterior to the posterior carapacic furrow; length of carapace 0.71 mm., greatest width 0.51 mm., width across the posterior margin 0.48 mm. Tergites, except I, II, and XI, completely divided; surface with scalelike markings; first tergite with 18 setae, second tergite with 18 to 20 setae, about 12 setae on each half-tergite of the central portion of the abdomen; all setae acuminate. Sternites divided; sculpturing as on the tergites; each fourth sternal half with 11 to 12 setae excluding those associated with the stigmata; each sternal half of the central part of the abdomen with as many as 18 setae. Each anterior stigmatic plate with three setae, each posterior plate with four; pleural membranes marked by numerous parallel striations; abdomen about 1.5 mm. long, width about one-half the length.

Chelicera.—Essentially as described above for *oblongus*; serrula exterior with 16 ligulate plates; length of chelicera approximately 0.17 mm., width of base about 0.115 mm., length of movable chelal finger 0.165 mm.

Palp.—Fig. 29A. Brownish-orange to golden in color; setae numerous and acuminate to subacuminate, frequently with a few subterminal and terminal spinules; segments stout to very stout; the sides of the maxilla, the entire trochanter, and the inner or flexor surfaces of the femur, tibia, and chela moderately granulate; also weakly granulate on the extensor surface of the chelal hand near the finger base. Maxilla 0.345 mm. long, about 0.21 mm. wide. Trochanter with well-developed subdorsal and sublateral protuberances, the former anterior to the latter; pedicle about as long as wide; trochanter 0.32 mm. long, about 0.2 mm. wide. Femur very stout; inner margin distinctly S-shaped; extensor margin markedly convex; pedicle about as long as wide, a distinct notch near the distal end of the flexor margin; length measured along the extensor margin (but not following the curvatures) 0.52 mm., greatest length 0.56 mm., width 0.24 mm. Tibia club shaped, swollen beyond the pedicle, which is much longer than wide; inner margin evenly convex beyond the pedicle; extensor margin flattened at least in the basal one-half and convex beyond; 0.545 mm. long, 0.248 mm. wide. Chela with the hand suboval in outline, fingers a little curved and fairly stout;

flexor margin of chelal hand moderately convex and extending without interruption into the basal margin; extensor margin less convex but not flatly convex; pedicle about as long as wide; chela, without pedicle, 0.85 mm. long, 0.29 mm. wide; chelal hand, without pedicle, 0.45 mm. long, 0.275 mm. deep; movable finger 0.43 long. As viewed from side, chelal hand, fig. 29B, subovate; fixed finger straight, movable finger curved; fingers gaping when closed; marginal teeth contiguous, cuspid, about 35 on each finger; fixed finger with three external and two internal accessory teeth; movable finger with five external and one internal accessory teeth; nodus ramosus of movable finger about two areolar diameters proximad from tactile seta *t*. Tactile setae placed as shown in the figure.

Legs.—First and second legs weakly granulate, granules merging into scalelike sculpturing on the third and fourth legs; setae acuminate, fairly numerous. First leg with pars basalis 0.113 mm. deep; pars tibialis with both margins moderately convex, 0.113 mm. deep; entire femur 0.35 mm. long; tibia very weakly S-shaped, 0.262 mm. long, 0.076 mm. deep; tarsus subcylindrical, 0.225 mm. long, 0.053 mm. deep. Fourth leg with extensor margin of femur evenly convex, flexor margin nearly straight; pars basalis 0.132 mm. deep, pars tibialis 0.165 mm. deep; entire femur 0.49 mm. long; tibia with flexor margin weakly convex, extensor margin nearly straight except at the base, a tactile seta on the extensor margin very near the distal end, tibia 0.38 mm. long, 0.102 mm. deep; tarsus subcylindrical, 0.274 mm. long, 0.07 mm. deep; tactile seta of tarsus located 0.1 mm. from the proximal margin.

Genital Complex.—Anterior operculum with 30 scattered setae; posterior operculum with 18 to 20 setae arranged chiefly in a marginal row and with two pairs of setae on the posterior rim of the aperture.

FEMALE.—Measurements and ratios based on three individuals, including the allotype. Like the male except as noted below. Each fourth sternal half usually with four setae. All tergites except the eleventh frequently divided. Body 2.0–2.5 mm. long; carapace 0.65–0.73 mm. long, 0.55–0.6 mm. wide; posterior width between 0.5 and 0.6 mm.; abdomen 1.3–1.85 mm. long, width equal to about one-half the length.

Chelicera.—Between 0.18 and 0.19 mm.

long, base between 0.115 and 0.135 mm. wide; movable finger 0.16–0.18 mm. long; serrula exterior with 16 to 18 ligulate plates.

Palp.—Maxilla 0.32–0.35 mm. long, 0.22–0.24 mm. wide. Trochanter 0.31–0.355 mm. long, 0.19–0.22 mm. wide, length about 1.6 times the width. Femur 0.48–0.56 mm. in length along the extensor margin, 0.22–0.255 mm. wide, length along the extensor margin about 2.2 times the width; greatest length 0.54–0.6 mm., 2.35 to 2.45 times the width. Tibia 0.515–0.585 mm. long, 0.225–0.27 mm. wide, length 2.15 to 2.3 times the width. Chela without pedicle 0.84–0.93 mm. long, 0.28–0.335 mm. wide, length 2.78 to 2.97 times the width; chelal hand exclusive of pedicle 0.445–0.51 mm. long, depth a little less than the width; movable finger 0.435–0.48 mm. long. Chelal fingers with usually 30 to 35 marginal teeth; 4 to 5 teeth in the external row of accessory teeth on each finger and 1 or 2 in the internal row on each finger. Tactile setae located essentially as in the male.

Legs.—Segments of first leg measure as follows: pars basalis 0.11–0.135 mm. deep; pars tibialis 0.107–0.13 mm. deep; entire femur 0.35–0.385 mm. long, 2.85 to 3.18 times the depth; tibia 0.255–0.285 mm. long, 0.074–0.087 mm. deep, length 3.28 to 3.47 times the depth; tarsus 0.22–0.24 mm. long, 0.053–0.059 mm. deep, length 4.08–4.22 times the depth. Fourth leg: pars basalis 0.13–0.152 mm. deep; pars tibialis 0.152–0.177 mm. deep; entire femur 0.49–0.56 mm. long, length 3.12 to 3.22 times the depth; tibia 0.373–0.405 mm. long, 0.1–0.113 mm. deep, length 3.58 to 3.85 times the depth; tarsus 0.277–0.3 mm. long, 0.068–0.07 mm. deep, length 3.95 to 4.07 times the depth; tactile seta of tarsus located 0.085–0.1 mm. from the proximal margin.

Genital Complex.—Anterior operculum with 22 to 24 (in one individual, only 17) setae; posterior operculum with a row of 10 setae.

Holotype, male.—Urbana, Illinois, March 27, 1938, H. H. Ross.

Allotype, female.—Same data as for holotype.

Paratypes.—ILLINOIS.—URBANA: Same data as for holotype, 2 ♀. ROCHESTER, Sangamon County, Oct. 3, 1943, H. R. Lowenstam, 1 ♀ (IM).

The Urbana collection was from a rotten log; the Rochester collection, from the underside of a stone slab in a yard.

Subfamily CHERNETINAE

This subfamily constitutes the most conspicuous and important group in our fauna. A member of the subfamily may be recognized by the straight or evenly convex posterior margin of the carapace; by the many short and either toothed or more or less club-shaped setae of the palps and dorsum of the body; and by the tactile seta of the

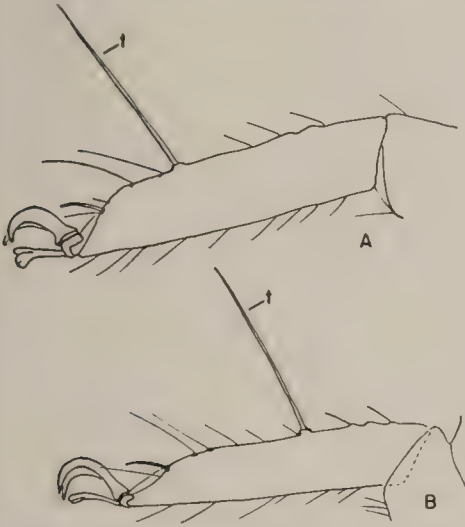


Fig. 31.—Tarsus of fourth leg showing tactile seta, *t*. A, *Parachernes squarrosus* ♂; B, *Pselaphochernes parvus* ♀.

fourth tarsus being located near the middle, or distad from the middle, of the segment.

The present scheme of classification within the subfamily is entirely unstable and unsatisfactory. In order to circumvent confused concepts of some older genera, the writer has established several new ones even though there is a possibility that one or more of these may later lapse into synonymy. A comprehensive revision of the entire subfamily is needed.

In the following key to genera, two points may give the student considerable trouble. The setae on the flagellum of chelicera, mentioned in couplet 8, are often difficult to distinguish, and therefore observations should be made of several specimens wherever possible. Great care must be taken with respect to identification of the tactile seta of the fourth pedal tarsus mentioned in couplet 12, since the seta is easily broken and lost. Also, the seta may be of reduced

size. If it is, there is sometimes confusion over whether or not a true tactile seta is present. A true tactile seta varies from an ordinary seta of the vestiture by having greater length, by being entirely acuminate, and by being directed at more of a right angle to the surface of the segment, fig. 31.

KEY TO GENERA

1. Cheliceral galea about two-thirds as long as the movable cheliceral finger.....
.....23. *Genus? corticis*
- Cheliceral galea much less than two-thirds as long as the movable finger of the chelicera.....2
2. Internal surface of chelal hand with a large, projecting, anvil-shaped structure, fig. 45C. Males of.....
.....21. *Mirochernes*
- Internal surface of chelal hand without such projection.....3
3. All interior setae of fixed chelal finger grouped in the basal portion of the finger, fig. 32E.....12. *Parachernes*
- At least *it* situated beyond middle of fixed finger.....4
4. Palp slender, palpal femur about four times as long as wide.....
.....17. *Pseudozaona*
- Palp less slender, moderate to very stout.....5
5. Setae of palp leaflike and bilaterally feathered.....22. *Illinichernes*
- Setae of palp otherwise.....6
6. Tactile seta *st* of movable chelal finger closer to *sb* than to *t*.....
.....15. *Dendrochernes*
- Tactile seta *st* midway between *sb* and *t* or nearer the latter.....7
7. Tactile seta *ist* of fixed chelal finger on the same level as *est* or a little proximad to *est*.....8
- Tactile seta *ist* distad from *est*.....9
8. Cheliceral flagellum composed of four setae; no tactile seta on fourth pedal tarsus; in our form, the palpal femur and tibia each have a length greater than 0.75 mm.....13. *Chelanops*
- Flagellum composed of three setae; a tactile seta present on fourth pedal tarsus; length of femur and of tibia less than 0.6 mm.....
.....14. *Pselaphochernes*
9. Setae *b* and *sb* of cheliceral hand thickened and denticulate.....
.....19. *Hesperochernes*
- Not as above, at least seta *b* acuminate.....10
10. Both seta *b* and seta *sb* of cheliceral hand acuminate.....20. *Acuminochernes*
- Seta *b* of cheliceral hand acuminate, *sb* denticulate.....11
11. Palp with following combination of

characters: length-width ratio of palpal femur about 2.3:1; length of chela exclusive of the pedicle divided by length of femur usually between 1.7 and 1.8; length of chela greater than 1.0 mm.; length of femur more than 0.6 mm.; tactile seta present on tarsus of fourth leg. Females of. **21. Mirochernes**

Some other combination of palpal characters; tactile seta absent from or present on tarsus of fourth leg. **12**

12. No tactile seta on tarsus of fourth leg; combination of length-width ratio of femur 2.3-2.5:1 and of chela 2.6-2.75:1

. **16. Reginachernes**
Tactile seta present on tarsus of fourth leg; Illinois species having a similar length-width ratio of both femur and chela (exclusive of pedicle) of palp, either both greater than 2.6, or both less than 2.5. **18. Dinocheirus**

12. PARACHERNES Chamberlin

Parachernes Chamberlin (1931*b*, p. 192).
Genotype, by original designation: *Parachernes ronnaii* Chamberlin.

Parachernes Chamberlin. Beier (1932*c*, p. 116).

Members of this genus can be recognized by the grouped condition on the fixed chelal finger of the tactile setae *it*, *ist*, *isb*, and *ib*, with *it* clearly farther from the finger tip than from *isb*, fig. 32*E*; flagellum of three setae; eye spots mostly present; tergites divided; setae of body and palp toothed or feathered, seldom lightly clavate; tactile seta *st* of movable chelal finger only a little nearer to *sb* than to *t* or standing in the middle between the two, fig. 32*E*; tactile seta of the fourth pedal tarsus located distad from the mid-point of the segment. A single species is known from the north-central states.

Parachernes squarrosus new species

Chelanops pallidus Ewing (1911, p. 78), (*non Chernes pallidus* Banks). Misidentification.

The present species figs. 32*A*-32*E*, bears considerable relationship to two species described by Nathan Banks, *Parachernes pulchellus* from Texas and *virginicus* from Virginia. From *pulchellus*, *squarrosus* may be distinguished by the absence of silver blotches on the outer ends of the abdominal tergites and by the flatly convex rather than evenly convex outer margin of the palpal femur. From *virginicus*, this new species can be distinguished by the more granular nature of the palpal segments, the fewer plates in

the serrula exterior, and the slightly different size and length-width ratio of the palpal femur.

Among the local fauna, *squarrosus* can be identified readily on the basis of the lightly colored silver blotches along the posterior margin of the carapace. No other Illinois pseudoscorpion has such a pigment pattern.

Two specimens from Ewing's collections were found to belong to this species. One specimen, a female, deposited in the Museum of Comparative Zoology, had been labeled *Chelanops virginica* but this name had been deleted and the identification *C. pallidus* supplied. This specimen was apparently reported by Ewing (1911) under the name *pallidus* from "under bark" at Arcola, Illinois. The date of collection of this specimen was June 12, 1908. The second specimen available from the Ewing collections is a male deposited at the Cornell University Museum. The slide of this specimen bears the deleted name *Chelanops pallidus*, which was replaced by the identification *Chelanops sanborni*. The specimen was taken under the bark of a living oak tree at Marshall, Illinois, on October 10, 1908. Since Ewing (1911) reported *pallidus* but not *sanborni* from Marshall, this specimen was probably reported as *pallidus*.

The erroneous identification of the present species as *pallidus* (Banks) is easily explained since, during the time Ewing worked, generic and specific characters were poorly understood and inadequately described. We now know that the species *pallidus* belongs to the genus *Dinocheirus* as indicated elsewhere in this paper. Cleared specimens of *Dinocheirus pallidus* and *Parachernes squarrosus* are superficially similar and can easily be confused. However, the cheliceral flagellum of *pallidus* has four setae while there are only three setae in the cheliceral flagellum of *squarrosus*.

MALE.—Measurements and ratios are given as the limits of variation of three individuals, including the holotype. Body and palps fairly stout, legs moderately slender; body and appendages for the most part distinctly granular; color varying from yellow on the legs to reddish or golden brown to brown on the palps and carapace, and dark brown on the tergites; body 1.8-1.9 mm. long. Carapace, fig. 32*A*, with surface coarsely granular except for a transversely placed white blotch along the posterior margin on each side of the median line; posterior mar-

margin with 8 to 12 subclavate to clavate marginal setae placed just anterior to the white blotches; anterior margin weakly convex, with four stout setae, each with a few subterminal and terminal denticulations; carapace narrowed rapidly anterior to the mid-point, posterior portions of lateral margins of two sides nearly parallel; the median transverse furrow near the mid-point of the face of the carapace, the posterior furrow anterior to the white blotch of each side and a little closer to the posterior carapacic margin than to the median furrow; setae of face and sides of carapace short, slender, subclavate or paucidenticulate; a single pair of eye spots; carapace 0.65–0.7 mm. long, width just posterior to the center of the carapace 0.5–0.6 mm.; ocular width about 0.3 mm. Abdomen suboval in general shape; 1.1–1.3 mm. long; 0.8–0.9 mm. wide. Tergites except the eleventh divided; dark brown in color; granulations very similar to those

of the carapace; the medial end of some of the tergites lighter in color than the rest of the tergite; the lateral ends of tergites not bearing lightly colored blotches; each tergite with a single row of marginal setae and, in addition, frequently with a lateral seta at each outer end of the tergite; setae of all but the eleventh tergite weakly clavate; four to seven setae on each half-tergite; eleventh tergite with four to five pairs of subacuminate to acuminate setae. Sternites 4 through 10 divided; sternites dark brown, surface marked by scalelike or netlike impressions; setae acuminate, moderately long, very slender; fourth sternite with eight setae; each of sternites 5 through 10 with 12 to 18 setae; sternite 11 with three pairs of setae, the medial and lateral pairs of which are very long. Pleural membranes with wavy parallel striations; anterior stigmatic plate with one or two acuminate setae, posterior plate with one.

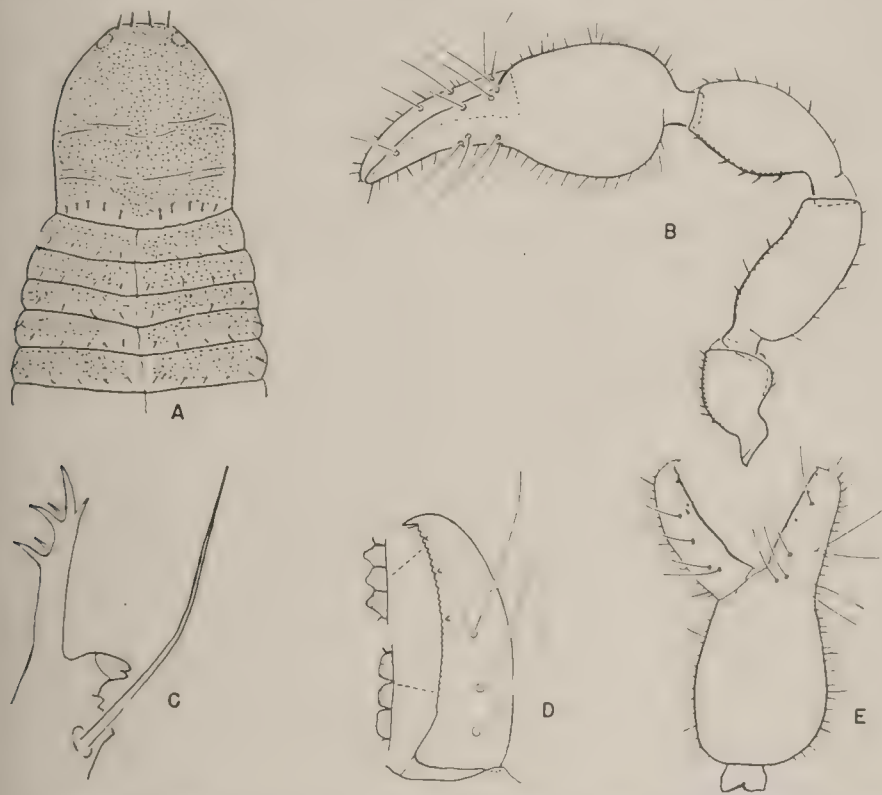


Fig. 32.—*Parachernes squarrosus*. A, dorsal view of carapace and five anterior tergites, holotype ♂; B, dorsal view of palp, holotype ♂; C, galea and tip of movable chelicerar finger, paratype ♂; D, lateral view of movable chelal finger with teeth enlarged, paratype tritonymph; E, lateral view of chela, allotype ♀.

Chelicera.—Light brown in color, sometimes with a greenish tinge; 0.185–0.19 mm. long, base about 0.12 mm. wide; movable finger 0.16–0.17 mm. long. Flagellum of three setae, the longest having six to eight fine denticulations along the distal half of the anterior margin. Fixed finger with conspicuous lamina exterior; most teeth of the serrula interior fused, but the distal four teeth free and with serrate margins; inner margin of finger with three retroconical teeth near the distal end; apical tooth acute and with three small, rounded denticles on the inner surface. Movable finger, fig. 32C, fairly stout, slightly curved; apical tooth well developed, terminally split to form two cusps; subapical tooth weakly developed, located just distad from the insertion of the galeal seta; two small, conical denticles or accessory teeth sometimes found on the inner margin of the movable finger between the subapical tooth and the base of the apical tooth; galeal seta extending slightly beyond the tip of the galea; serrula exterior of 19 to 21 ligulate plates; galea fairly stout and straight, with six or seven simple rami confined to the terminal one-half or one-third of the galea; considerable variation in the stoutness of the galea.

Palp.—Fig. 32B. Lateral surface of maxilla, all surfaces of trochanter, and the flexor surfaces of the femur and tibia coarsely granulate; rest of palp weakly granular to smooth; setae varying from acuminate to subclavate and paucidentate. Maxilla with acuminate and slender setae; 0.295–0.305 mm. long, 0.22–0.23 mm. wide, length 1.35 to 1.4 times the width. Trochanter with inner margin regularly convex, surface bearing numerous short setae with terminal and subterminal denticulations; a well-rounded, dorsolateral protuberance present; trochanter 0.24–0.26 mm. long, 0.17–0.175 mm. wide. Femur with pedicle wider than long, well separated from the rest of the segment; extensor margin flatly convex, except at the ends; flexor margin distinctly S-shaped, concave in the distal half of the segment but distinctly convex in the proximal portion; granulations coarser and much more marked on the medial than on the sometimes nearly smooth, outer surface; setae of the medial surface sparse and subclavate, setae of the lateral surface somewhat longer and with few denticulations; femur 0.48–0.505 mm. long, 0.19–0.22 mm. wide, length 2.3 to 2.5 times the width.

Tibia pedicellate, with pedicle about as long as wide; outer margin of tibia including the pedicle evenly convex; inner margin centrally bulged and convex but slightly flattened in the distal one-third; setae much as in the femur; flexor or medial surface coarsely granulate; outer or lateral surface virtually smooth; 0.45–0.48 mm. long, 0.215–0.235 mm. wide, length 2.0 to 2.15 times the width. Chela stout; setae of hand relatively long, with one or two very fine submedial to subterminal denticulations on each; setae of fingers acuminate; hand with a few fine granulations on the inner aspect near the base of the fingers, otherwise smooth; flexor margin of chelal hand slightly more convex than the extensor; pedicle placed nearer the outer than the inner surface of the hand; fingers evenly curved; chela, without pedicle, 0.785–0.835 mm. long, 0.32–0.33 mm. wide, length 2.4 to 2.5 times the width; chelal hand 0.32–0.36 mm. deep, hand, without pedicle, 0.41–0.43 mm. long; movable finger about equal in length to length of hand without pedicle. As viewed from the side, dorsal margin of the chelal hand more convex than the ventral; the pedicle displaced toward the ventral side; fixed finger stout and nearly straight; movable finger distinctly curved. Marginal teeth of both fingers contiguous; distal teeth acute and each with a well-marked cusp, proximal teeth more rounded and with weak cusps; 30 to 35 marginal teeth on each finger; each finger with five to seven external and two or three internal accessory teeth. Tactile setae as in fig. 32B; nodus ramosus of movable finger located slightly proximad from the areole of tactile seta *t*.

Legs.—Surfaces, except the posterior, or the basal segments of legs fairly well marked by scalelike sculpturing, becoming weaker on the distal segments; setae variable. First leg with stout trochanter, 0.11–0.115 mm. long; pars basalis 0.115–0.12 mm. deep; pars tibialis almost smooth to coarsely granulate, 0.107–0.122 mm. deep; entire femur 0.3–0.35 mm. long; tibia with extensor margin weakly S-shaped, greatest depth in the distal one-fourth, 0.23–0.25 mm. long, 0.072–0.087 mm. deep, length 2.85 to 3.2 times the depth; tarsus subcylindrical, with weak sculpturing, setae not abundant, 0.23–0.24 mm. long, 0.053–0.057 mm. deep, length 4.2 to 4.4 times the depth. Fourth leg with pars basalis almost smooth, a few long acuminate setae on the flexor surface, subtriangular in

line, 0.137–0.14 mm. deep; pars tibialis with anterior surface conspicuously sculptured, posterior surface almost smooth, extensor margin almost straight, 0.165–0.175 mm. deep; entire femur 0.44–0.465 mm. long, length 2.65 to 2.75 times the depth; tibia with extensor margin slightly S-shaped, almost straight, 0.35–0.37 mm. long, 0.095–0.102 mm. deep, length 3.65 to 3.85 times the depth; tarsus subcylindrical, numerous acute setae on the flexor surface, a few relatively long and subterminally denunculate setae on the extensor surface, weakly developed sculpturing, 0.28–0.30 mm. long, 0.065–0.0685 mm. deep, length 4.3 to 4.5 times the depth; a long and slender tactile seta inserted 0.165–0.19 mm. from the proximal margin of the tarsus.

Genital Complex.—Anterior operculum with usually 8 to 12 marginal setae near the anterior margin of the genital aperture and with as many as 30 setae more anteriorly located on the operculum; posterior operculum with 6 to 10 setae on the posterior margin of the genital aperture and 8 to 10 widely separated and very slender setae in a transverse row between the genital slit and the posterior margin of the operculum.

Female.—Measurements and ratios based on four individuals, including the allotype. In general, much like the male; body length 1.5–2.20 mm.; carapace 0.675–0.75 mm. long, width 0.85 to 0.95 times the length; palpal width 0.32–0.34 mm.; abdomen 1.15–1.50 mm. long, 0.9–1.05 mm. wide.

Chelicera.—Similar to the male; 18 to 19 plates in the serrula exterior; length of chelicera 0.2–0.215 mm., width of base 0.13–0.14 mm., length of movable finger 0.175–0.19 mm.

Palp.—Segments slightly larger than in the male but the length-width ratios almost identical in the two sexes; maxilla 0.33–0.35 mm. long, 0.25–0.28 mm. wide, length 1.2 to 1.45 times the width; trochanter 0.26–0.27 mm. long, 0.18–0.195 mm. wide, length 1.35 to 1.45 times the width; femur 0.52–0.535 mm. long, 0.215–0.225 mm. wide, length 2.35 to 2.5 times the width; tibia 0.48–0.495 mm. long, 0.235–0.25 mm. wide, length 1.95 to 2.05 times the width; chela, without pedicle, 0.865–0.885 mm. long, 0.34–0.375 mm. wide, length 2.37 to 2.55 times the width; chelal hand exclusive of pedicle 0.47–0.485 mm. long, 0.34–0.38 mm. deep; movable finger 0.445–0.465 mm. long. Teeth, both marginal and accessory, much

as in the male except slightly more variation in number. Tactile setae arranged as in the male.

Legs.—Essentially as in the opposite sex; some segments, however, slightly larger in actual size and sometimes a little more extensively granulate. First leg with trochanter 0.115–0.125 mm. long; pars basalis 0.123–0.133 mm. deep; pars tibialis 0.12–0.13 mm. deep; entire femur 0.33–0.375 mm. long; tibia 0.24–0.26 mm. long, 0.08–0.085 mm. deep, length 2.8 to 3.05 times the depth; tarsus 0.235–0.255 mm. long, 0.06–0.065 mm. deep, length 3.8 to 4.2 times the depth. Fourth leg with trochanter 0.19–0.195 mm. long, length 1.3 to 1.65 times the depth; pars basalis 0.145–0.16 mm. deep; pars tibialis 0.17–0.19 mm. deep; entire femur 0.48–0.515 mm. long, length 2.6 to 3.0 times the depth; tibia 0.36–0.39 mm. long, 0.1–0.112 mm. deep, length 3.35 to 3.85 times the depth; tarsus 0.285–0.31 mm. long, 0.069–0.075 mm. deep, length 4.0 to 4.45 times the depth; sensory seta 0.175–0.195 mm. from proximal margin of tarsus.

Genital Complex.—Anterior operculum with between 20 and 25 (in one individual only 17) setae arranged chiefly in a medially placed triangular group; posterior operculum with six or eight widely scattered setae arranged in a single marginal row.

TRITONYMPH.—Description based on two individuals. Measurements of one are given in parentheses after the corresponding measurements of the other whenever the two differ significantly. Same general features as in the adult except that the body is less darkly colored and less sclerotic; length 1.65 mm. Carapace light yellowish-brown; white blotches near the posterior margin fused medially to form a single transverse bar anteriorly to and isolating a small median pigmented area lying near the posterior margin of the carapace; carapace 0.55 (0.575) mm. long, with the greatest width but little less than the length. Abdomen much as in the adult; tergites, however, lighter in color and less sclerotic; setae of tergites less clavate and in some cases almost acuminate; sternites as in the adult except less darkly colored, not so coarsely granular, and with fewer setae.

Chelicera.—In general with the characteristics in the adult; serrula exterior with 16 or 17 ligulate plates; chelicera 0.16 (0.17) mm. long, base 0.1 (0.11) mm. wide, movable finger 0.15 mm. long.

Palp.—In general shape, chaetotaxy, and sculpturing much as in the adult; the pedicels of the femur and tibia are much wider than long and poorly separated from the rest of the segment; tibia a little stouter and the chela a little more slender than in the adult. Maxilla 0.285 mm. long, trochanter 0.205 (0.215) mm. long, femur 0.38 mm. long; tibia 0.355 (0.34) mm. long, 0.195 mm. wide; chela 0.695 (0.675) mm. long, 0.262 (0.258) mm. wide; chela depth about 0.26 mm., hand length 0.37 mm.; movable chelal finger 0.36 (0.35) mm. long. Marginal teeth, fig. 32*D*, of each finger between 25 and 30 in number; the distal 8 to 12 teeth of the marginal row of each finger acute and with well-formed cusps, other teeth blunt, rounded, with very weak cusps or without cusps; accessory teeth fewer in number and more weakly developed than in the adult. The three tactile setae of movable finger as shown in fig. 32*D*. Fixed finger with four tactile setae in external series, arranged much as in the adult male; internal series of three tactile setae with *it* slightly more than twice as far from the finger tip as from the level of *et* and somewhat distad from the level of *est*; *isb* and *ib* as in the adult; *ist* wanting.

Legs.—In general as in the male, except segments a little stouter, lighter in color, less sclerotic, and with fewer setae. First leg with entire femur about 0.25 mm. long; tibia with extensor margin straight except at the proximal end, 0.18 (0.175) mm. long, length 2.6 (2.4) times the depth; tarsus with both margins more convex than in the adult, 0.185 (0.19) mm. long, length about 3.2 times the depth. Fourth leg with pars basalis about 0.13 mm. deep; pars tibialis 0.15 (0.155) mm. deep; entire femur 0.375 mm. long, length 2.5 (2.4) times the depth; tibia with extensor margin almost straight, 0.29 (0.277) mm. long, 0.087 (0.08) mm. deep; tarsus with both margins conspicuously convex, 0.22 (0.225) mm. long, about 0.075 mm. deep; sensory seta of tarsus shorter than in the adult and inserted 0.115 (0.13) mm. from the proximal margin of the segment.

Holotype, male.—Fowler, Illinois: bark of oak tree, July 19, 1944, C. C. Hoff.

Allotype, female.—Karnak, Illinois: Feb. 24, 1933, Ross & Mohr.

Paratypes.—ILLINOIS.—ARCOLA: under bark, June 12, 1908, H. E. Ewing, 1 ♀ (MCZ). CARBONDALE: jarred from willow

and sycamore branches, Sept. 22, 1908, L. N. Smith, 11 nymphs and adults. CENTRALIA: under pear bark, June 18, 1947, L. J. Stannard, 1 ♂. FOWLER: same data as for holotype, 1 ♂ (JC). KARNAK: same data as for allotype, 1 ♀. LAKE GLENDALE: ground cover, March 17, 1943, Ross & Sanderson, 1 nymph. MARSHALL: under bark of living oak tree, Oct. 10, 1908, H. E. Ewing, 1 ♂ (CU). QUINCY: near Benton's Cave, inner layer of bark on log, April 27, 1944, C. C. Hoff, 1 ♂ (CH); nest in bluebird box, Oct. 30, 1945, T. E. Musselman, 1 nymph (CH). URBANA: under bark of maple, June 18, 1942, K. M. Sommerman, 1 ♂; under bark, July 20, 1944, K. M. Sommerman, 1 ♀.

This species is usually found under the bark of deciduous trees or logs but may occasionally be taken in woody debris and forest ground cover. The tritonymph collected at Quincy by T. E. Musselman was taken from a nest in a bluebird box.

13. *CHELANOPS* Gervais

Chelanops Gervais, in Gay (1849, p. 13).

Genotype, monobasic: *Chelifer* (*Chelanops*) *coecus* Gervais.

Chelanops Gervais. Beier (1932c, p. 177), Hoff (1947, p. 503).

Carapace somewhat longer than wide, granular; tergites divided, granular. Setae of body and palps somewhat variable, plumose, and usually appearing subclavate to clavate. Flagellum with four setae. Palp, fig. 33, moderately heavy, granular; tactile seta *ist* placed on the same level with *est* or a little proximad from *est*; *st* nearer to *t* than to *sb*. Tarsus of fourth leg without a tactile seta.

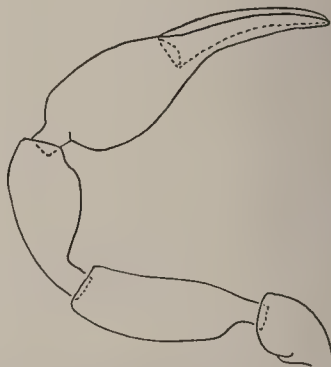


Fig. 33.—*Chelanops affinis* ♂. Dorsal view of palp (setae omitted).

The genus is confined to the Americas, chiefly South and Central America and the West Indies, and, as now limited, contains a small number of species. One species, *Chelanops affinis* Banks, is recorded from Florida. Many species were assigned to *Chelanops* by earlier authors, but most of them have been transferred to other genera.

14. *PSELAPHOCHERNES* Beier

Pselaphochernes Beier (1932c, p. 130), (1933, p. 520). Genotype, by original designation: *Chelifier scorpioides* Hermann.

Cephalothorax somewhat longer than wide, fig. 34D, fairly well granulated; setae of body and palps moderately long, toothed, and often lightly clavate; three blades in the cheliceral flagellum; a single internal accessory tooth on each chelal finger; fixed finger with short and vestigial venedens and duct; tactile seta *ist* of the fixed finger on about the same level as *est*. Internal series of tactile setae not forming a basal group, fig. 34B; seta *st* a little nearer to *t* than to *sb* or about midway between the two; tarsus of fourth leg with a tactile seta near the mid-point or slightly proximad from the mid-point of the segment.

Except for a doubtful record of the European *scorpioides* from the eastern United States, only the following species is known from the nearctic region.

Pselaphochernes parvus Hoff

Pselaphochernes parvus Hoff (1945a, p. 38).

Diagnostic characters of the species are illustrated in fig. 34. A full description of the female is given in the original description. Study of the present material has brought to light the undescribed male of the species and has led to a clearer demonstration of the differences between *parvus* and the closely related European species, *scorpioides* (Hermann). Several characteristics that can be expressed numerically serve to separate the two forms. The chela of the female of *parvus* has a length 2.9 to 3.15 times the width, while in *scorpioides* the chela is 2.7 times as long as wide; in the male of *parvus* the femur is 0.45–0.51 mm. long, in *scorpioides* 0.43 mm.; the chela of the male of *parvus* is 3.1 to 3.2, but in *scorpioides* 2.9, times as long as wide; in *parvus* the movable chelal finger of the male is 0.41–0.45 mm. long, in *scorpioides* 0.38 mm. Measurements for *scorpioides* have been taken from Beier (1932c). There is

also a distinct difference between the two species in the amount of flattening of the outer margin of the chelal hand, our Illinois species, fig. 28, having a much more flattened margin than does *scorpioides* as figured by Beier (1932c). An atypical male in one of the collections appears to resemble the male of *scorpioides* as figured by Beier (1932c), but the length of the palpal segments and the somewhat flattened external margin of the chelal hand indicate that the individual is not *scorpioides*.

MALE.—Measurements and ratios are based on four individuals. Body moderately stout; yellow in color except for light brown or golden colored palps; 1.5–1.9 mm. long; carapace, fig. 34D, with straight to slightly convex posterior margin and with 8 to 10 marginal setae; anterior margin bluntly rounded and with four setae; anterior half of each lateral margin convex, posterior half of lateral margins straight and parallel; median and posterior transverse furrows not well marked; surface moderately granular, light brown in color; numerous setae scattered over the face and sides; setae subclavate, with a few terminal denticulations; no eye spots; length of carapace 0.53–0.61 mm., greatest width 0.45–0.51 mm. near center, posterior width almost equal to the greatest width. Abdomen 0.95–1.3 mm. long, 0.6–0.72 mm. wide; length 1.5 to 1.8 times the width. Tergites weakly sclerotic, inconspicuously divided except the eleventh; half-tergites each usually with five to seven (occasionally eight) widened and terminally paucidenticulate setae. Sternites 4 through 10 divided, most half-sternites with from 9 to 11 (occasionally more) acuminate setae, chiefly confined to a marginal row; fourth sternite with three to five setae forming a marginal row in each half-sternite. Pleural membranes marked by wavy, subpapillose, longitudinal plications. Each anterior stigmatic plate with one seta; each posterior plate with two.

Chelicera.—Length 0.175–0.195 mm., width 0.11–0.125 mm., the laminal and interior setae acuminate, simple, much longer than the basal and subbasal; basal, subbasal, and exterior setae denticulate along the distal fourth. Flagellum of three blades, the distal one bearing 10 to 12 denticulations on the anterior edge along the distal two-thirds. Fixed finger with well-developed lamina exterior; the serrula interior with five free and serrate marginal teeth, remain-

der fused into a velum; apical tooth with two or three internal denticles; the internal margin of finger with six or seven denticles arranged along the distal one-third of the finger. Movable finger, fig. 34A, 0.173–0.185 mm. long; serrula exterior of 18 ligulate plates, the basal one or two but little longer than the remainder; subapical lobe close to end of finger and subequal in size to the apical or terminal tooth; galeal seta extending just beyond the tip of the galea; galea less well developed than in the female, usually with two main rami, each of which is in turn branched or bifurcated.

Palp.—Fig. 34C. Moderately granular except that the fingers are smooth and the flexor surfaces of the femur and tibia are coarsely granular; setae subclavate to acuminate. Maxilla with scattered acuminate setae; 0.275–0.31 mm. long; length about 1.5 times the width. Trochanter with two protuberances, coarsely granular; numerous multidenticulate setae on inner surface; length 0.255–0.275 mm., 1.45 to 1.55 times the width. Femur with pedicle about as long as wide; extensor margin convex and with numerous setae varying from short and multidenticulate near the base to longer and paucidenticulate near the distal end; flexor surface coarsely granular and with a few setae like those of the trochanter; flexor

margin weakly S-shaped; length measured along the extensor margin 0.45–0.51 mm. maximum over-all length a little greater; 0.17–0.195 mm. wide; length 2.55 to 2.6 times the width. Tibia slightly shorter and wider than the femur; granulations and chaetotaxy much as in the femur; extensor margin somewhat flatly convex but more convex toward the distal end; flexor margin bulging in the center; 0.435–0.485 mm. long; 0.185–0.215 mm. wide; length 2.23 to 2.3 times the width. Chela moderately slender; hand granulate and with long subacuminate setae, each with one or two subterminal denticulations; outer margin of chela flatly convex, inner margin more convex; finger curved; chela 0.75–0.83 mm. long, 0.24–0.26 mm. wide, length 3.1 to 3.2 times the width; 0.235–0.27 mm. deep; hand length without pedicle 0.385–0.43 mm.; finger slightly longer than hand without pedicle, measuring from 0.41–0.45 mm. Viewed laterally, fig. 34B, both dorsal and ventral margins of hand appear convex. Each finger with between 35 and 45 marginal teeth, contiguous, and with well-developed cusps; a single interior accessory tooth on each finger, located slightly more than one-fourth of finger length from the tip; usually seven or eight exterior accessory teeth on each finger, spaced along the distal three-fourths of the

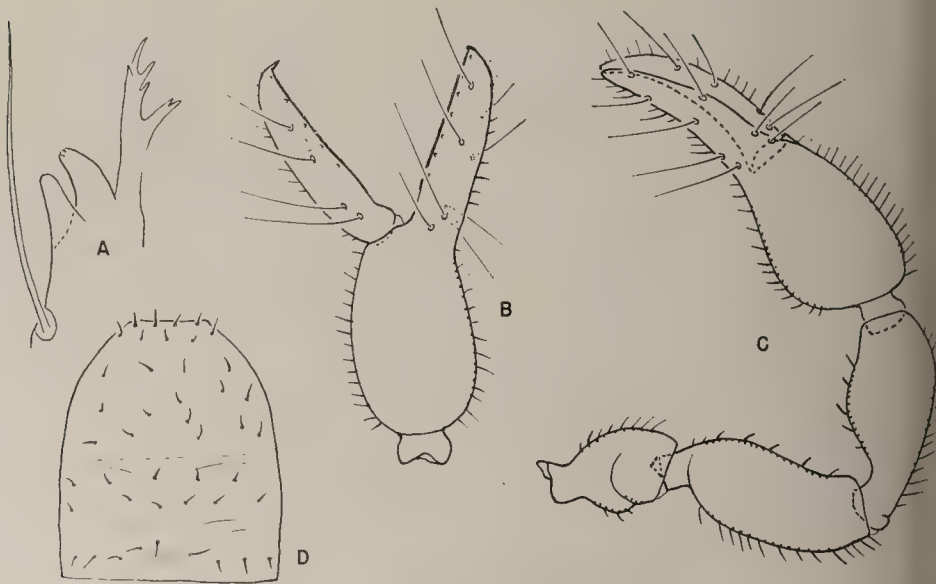


Fig. 34.—*Pselaphochernes parvus* ♂. A, tip of movable cheliceral finger; B, lateral view of chelal hand; C, dorsal view of palp; D, dorsal view of carapace.

finger length. Tactile setae of chelal fingers as shown in the figure.

Legs.—Yellow to very pale brown in color; moderately slender; subterminal setae and tarsal claws simple and entire; surface usually weakly marked by scalelike lines; setae varying from paucidentate to acuminate. First leg with trochanter about 1.2 mm. long, several relatively long paucidentate setae on flexor surface as well as a long acuminate pseudotactile seta; pars basalis 0.125–0.135 mm. long, length 1.2 to 1.4 times the depth; pars tibialis with a weakly convex extensor margin, flexor margin more weakly convex and almost straight, setae of extensor margin short and paucidentate, those of flexor surface slightly longer and almost acuminate, length of pars tibialis 0.183–0.23 mm., depth 0.08–0.114 mm., length 2.0 to 2.3 times the depth; tibia with a very weakly S-shaped extensor margin, flexor margin weakly convex, chaetotaxy as in the pars tibialis, tibia 0.23–0.26 mm. long, 0.065–0.077 mm. deep, length 3.35 to 3.55 times the depth; tarsus with flexor margin slightly convex, extensor margin nearly straight, setae more numerous than on other segments, setae varying from terminally and subterminally denticulate on the basal part of the extensor surface to truly acuminate on the terminal portion of the segment; tarsus 0.24–0.27 mm. long, 0.05–0.054 mm. deep, length 4.6 to 5.1 times the depth. Fourth leg with chaetotaxy and sculpturing as in the first leg; trochanter with numerous setae, especially on the flexor surface, length 0.16–0.17 mm., 1.35 to 1.45 times the depth; pars basalis subtriangular, distal three-fourths of flexor margin straight, flexor surface with numerous long and subacuminate setae, length 0.16–0.175 mm., 1.3 to 1.45 times the depth; pars tibialis with extensor margin evenly and moderately convex, flexor margin straight and continuous with that of the pars basalis; pars tibialis 0.3–0.35 mm. long, 0.122–0.15 mm. deep, length 2.3 to 2.45 times the depth; entire femur 0.42–0.48 mm. long, length 3.2 to 3.45 times the depth; tibia with weakly S-shaped extensor margin and convex flexor margin, length 0.5 to 3.85 times the depth; tarsus with both flexor and extensor margins weakly convex, slightly narrowed distally, deepest near the level of the sensory seta, chaetotaxy much as in the tarsus of the first leg, 0.26–0.315 mm. long, 0.065–0.07 mm. deep, length 4.4 to 4.0 in one individual) to 4.75 times the

depth; sensory seta of the extensor surface of the tarsus located proximad from the mid-point of the segment, usually little more than 0.4 of the tarsus length from the proximal margin.

Genital Complex.—Anterior operculum with about 20 setae arranged in a crescent; posterior operculum with 8 to 10 (rarely 12) marginal setae; four (rarely five or six) setae on the posterior lip of the genital opening, almost within the opening, and anteriorly to the marginal row.

FEMALE.—Females much more numerous than males. Female differing but little from male; slightly larger, up to 2.2 mm. or more in length, often a little more darkly pigmented than the male. Carapace and abdomen not distinctly different in the two sexes.

Chelicera.—Slightly larger and with the galea more branched than in the male; otherwise almost identical in the two sexes.

Palps.—Most segments, especially the chela, slightly larger than in the male; otherwise similar. Chela (measurements based on 16 Illinois specimens) exclusive of pedicle 0.85–0.95 mm. long, 0.27–0.31 mm. wide, length 2.9 to 3.15 (rarely less than 3.0) times the width; movable finger 0.45–0.51 mm. long. Teeth and tactile setae of chela as in the male; length-width ratios of chelae of Illinois specimens on the average slightly less than the ratios for the type specimens from Arkansas (Hoff 1945a).

Legs.—Shape, chaetotaxy, and sculpturing essentially as in the male; segments, however, frequently larger; length-depth ratios about the same in the two sexes. The following measurements and ratios of certain pedal segments in the female are based on measurements of nine individuals: tibia of first leg 0.255–0.295 mm. long, 0.072–0.08 mm. deep, length 3.4 to 3.85 times the depth; tarsus of first leg 0.27–0.3 mm. long, 0.053–0.059 mm. deep, length 4.6 to 5.2 times the depth; pars tibialis of fourth leg 0.35–0.4 mm. long, 0.135–0.155 mm. deep, length 2.45 to 2.75 times the depth; tibia of fourth leg 0.345–0.385 mm. long, 0.09–0.1 mm. deep, 3.7 to 4.2 times as long as deep.

Genital Complex.—Anterior operculum with 14 to 18 setae; posterior operculum with 8 or 10 setae.

TRITONYMPH.—Measurements are based on three individuals mounted in balsam. Much like the adult but smaller and lighter in color; appendages stouter. Body 1.35–1.55 mm. long; carapace about 0.5 mm. long

and about 0.4 mm. wide; abdomen between 0.6 and 0.7 mm. wide. Chelicera essentially as in the adult. Palpal segments conspicuously and coarsely granular on the flexor surfaces, other surfaces moderately granular; chelal hand moderately granular; trochanter 0.22–0.23 mm. long, 0.13–0.14 mm. wide; femur with maximum length between 0.33 and 0.35 mm., length along the extensor margin 0.3–0.32 mm., width 0.14–0.15 mm., greatest length 2.3 to 2.5 times the width, length along the extensor margin 0.21 to 0.23 times the width; tibia about 0.33 mm. long, 0.16 mm. wide; chela 0.61 mm. long, 0.205–0.21 mm. wide, length between 2.9 and 3.0 times the width; depth of chelal hand subequal to the width; chelal hand 0.32 mm. long; movable chelal finger 0.29–0.31 mm. long. Tactile setae of the chelal fingers much as in the adult except *b* is missing from the movable finger and *ist* is wanting from the fixed finger; also *it* is much closer to the level of *est* than to the level of *et*, while in the adult *it* is closer to the level of *et* than to the level of *est*. Marginal and accessory chelal teeth much as in the adult except fewer in number.

DEUTONYMPH.—Two specimens examined. Smaller than the tritonymph but same general characteristics. Body length 1.0–1.05 mm., carapace about 0.38 mm. long. Serrula exterior of the movable cheliceral finger with 14 or 15 ligulate plates. Palpal segments smaller than in the tritonymph but with about the same length-width ratios. Palp with the following measurements (based on two individuals): trochanter about 0.17 mm. long, 0.1 mm. wide; femur with greatest length between 0.24 and 0.25 mm., width 0.11 mm.; tibia 0.23 to 0.24 mm. long, 0.12 mm. wide; chela exclusive of pedicle 0.45 to 0.46 mm. long, 0.148–0.155 mm. wide, length 2.9 to 3.1 times the width; chelal hand with length of 0.24 mm., depth about equal to the width; movable chelal finger 0.22 mm. long. Movable chelal finger with two tactile setae: one, probably *st*, near the mid-point of the finger and the second, probably *sb*, near the proximal margin; nodus ramosus a little distad from *st*. Fixed chelal finger with tactile setae much as in the tritonymph but with both *ist* and one of the external series, probably *esb*, wanting. Accessory teeth of chelal fingers apparently wanting.

PROTONYMPH.—Somewhat smaller and with conspicuously stouter appendages than

the deutonymph; body length about 0.9 mm. Serrula exterior of the movable cheliceral finger apparently of 11 plates. Chela exclusive of pedicle about 0.4 mm. long, about 0.14 mm. wide; chelal hand exclusive of pedicle 0.21 mm. long; movable finger equal in length to length of hand exclusive of pedicle. Movable finger with one tactile seta, probably *st*, located about two-fifths of the finger length from the proximal finger margin. Fixed finger with one tactile seta, probably *est*, located somewhat distad from the mid-point of the finger and one basal seta of the external series located near the finger base; internal series represented by a single tactile seta located about on a level with the single basal seta of the external series.

DISTRIBUTION.—Known only from Arkansas and Illinois; taken from scattered localities in all areas of the latter state. Habitat data are available for 25 collections. Sixteen of these collections were made from rotting logs or hollow trees and, in two of these, nests of small mammals were present. The other collections were made from woody debris and ground cover. The collections indicate a decided association with rotting wood as a preferred habitat.

Illinois Records.—Thirty collections, taken throughout the year, are from Cache, Caledonia, Elk Grove, Elsah, Grand Tower, Harrisburg, Herod, Kampsville, Karnak, La Rue, Makanda, Monticello, Mount Olive, Pere Marquette State Park, Quincy, Sherman, Urbana.

15. *DENDROCHERNES* Beier

Dendrochernes Beier (1932c, p. 171). Genotype, monobasic: *Chernes cyrneus* L. Koch. *Dendrochernes* Beier. Hoff. (1947, p. 536).

Carapace almost quadrate or a little longer than wide, weakly to moderately granular, the posterior transverse furrow nearer to the posterior carapacic margin than to the median transverse furrow. Tergites except the eleventh divided, finely to moderately granular. Setae of the body and palps toothed, not appearing clavate. Flagellum of four setae. Palp heavy, fig. 35, finely to moderately granular; tactile seta *ist* is almost at the same level as *est*, *st* is nearer to *sb* than to *t*. Tarsus of fourth leg with a sensory seta distad from the mid-point of the segment.

The genus is holarctic in distribution. In North America, *Dendrochernes morosus*

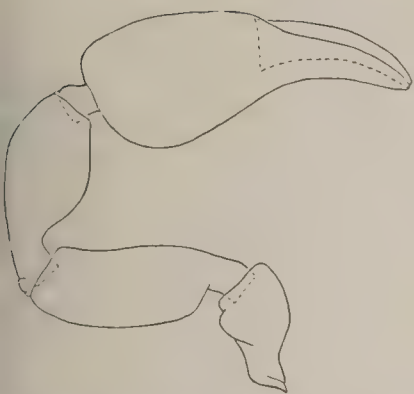


Fig. 35.—*Dendrochernes morosus* ♀. Dorsal view of palp (setae omitted).

Banks) is recorded from Isle Royale, Lake Superior.

16. REGINACHERNES new genus

DIAGNOSIS.—Chelicera with flagellum of four setae; seta *b* of cheliceral hand acuminate, *sb* stout and subterminally denticulate, fig. 36D; subapical lobe of movable cheliceral finger well developed, figs. 36E, 36F; *TC*, finger-like, and conspicuous; galea stout, with several simple terminal and subterminal rami. Palp stout; tactile seta *st* of movable chelal finger midway between *t*

and *sb* or somewhat closer to *t* than to *sb*, *ist* of fixed chelal finger distad from *est*, figs. 36A, 37B; setae of palp subclavate to clavate; little sexual dimorphism exhibited by palp; fixed chelal finger with reduced venedens and short vestigial venom duct, fig. 36B. Fourth leg with no true tactile seta on the tarsus, but with a denticulate pseudotactile seta near the distal end. Seminal receptacle of the female in the form of a long and slender tubule with a terminal sac or bulb.

Genotype.—*Reginachernes ewingi* new species.

Because it lacks a tactile seta on the tarsus of the fourth leg, the present genus appears closely related to the genus *Hesperochernes* Chamberlin, but differs in having the tactile seta *b* of the cheliceral hand acuminate and not denticulate as in *Hesperochernes*. The genus *Reginachernes* also bears some resemblance to *Allochernes* Beier, but the two genera differ in number of setae in the cheliceral flagellum.

KEY TO SPECIES

Length of chela exclusive of pedicle less than 0.9 mm., length of femur less than 0.55 mm.	 <i>ewingi</i>
Length of chela exclusive of pedicle more than 0.9 mm., length of femur more than 0.55 mm.	 <i>lymphatus</i>

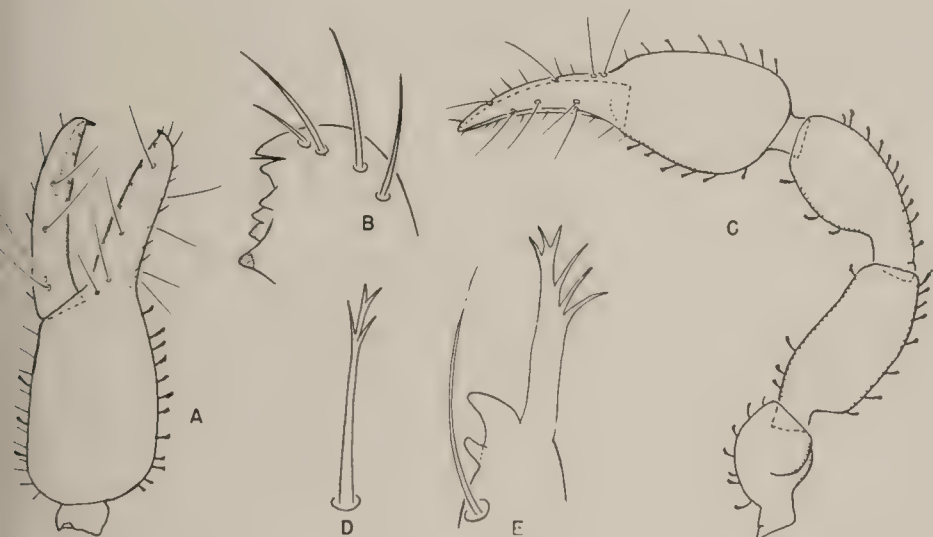


Fig. 36.—*Reginachernes ewingi*, holotype ♀. A, lateral view of chela; B, end of fixed chelal finger to show vestigial venedens; C, dorsal view of palp; D, tactile seta *sb* of the cheliceral hand; E, tip of movable cheliceral finger.

Reginachernes ewingi new species

Only two individuals, one male collected by Ewing more than 30 years ago, and one female, are available for study. Since the male is not in good condition for detailed examination, the female has been designated as the holotype fig. 36. The specimen collected by Ewing and deposited at the Museum of Comparative Zoology has, according to data accompanying the slide, been assigned successively to the species *Chelanops morosus* Banks and *Chelanops sanborni* (Hagen). The specimen appears to be more closely related to *Hesperochernes sanborni* as redescribed by Hoff (1946a) than to *Dendrochernes morosus* as also redescribed by Hoff (1947), but belongs to neither of these species. The present specimen appears not to have been reported by Ewing (1911) under either *Chelanops morosus* or *sanborni*, since the only specimens collected at Arcola and assigned by Ewing to the genus *Chelanops* were listed as *Chelanops pallidus*. It is possible that this specimen was not included in the report made by Ewing in 1911.

FEMALE.—Body and appendages fairly stout; abdomen, carapace, and legs brown; palps deeper golden brown; length of body about 2 mm. Carapace rounded anteriorly and laterally; surface coarsely granulate; anterior margin with 4 and the posterior margin with 8 to 10 setae; all carapacic setae distinctly clavate; greatest width near the center of the carapace, slightly narrower behind; length of carapace 0.65 mm., greatest width 0.66 mm. (or a little less, as the carapace may be somewhat flattened from mounting); posterior width 0.64 mm. Tergites a little deeper brown than the carapace; interscutal areas subpapillose and not pigmented; each tergal half with five to eight distinctly clavate setae. Sternites almost smooth, brown in color, all except the tenth divided and with scuta well separated; tergite 4 with nine setae; maximum number of setae on any sternal half is 10; all sternal setae acuminate. Pleural membranes with wavy, almost papillose, striations; each anterior stigmatic plate with three setae, each posterior plate with two.

Chelicera.—Yellow in color; fairly stout; palm of hand with netlike markings; longest flagellar seta serrate along almost the entire anterior edge. Fixed finger with two or three weak and rounded denticles on the inner margin of the apical tooth and two

strong and one or two very weak denticles on the inner finger margin near the distal end; lamina exterior evenly convex. Movable finger stout, fig. 36E; subapical lobe located near the base of the apical tooth; galeal seta not reaching to the tip of the galea; galea fairly stout and straight, with apparently six simple rami in the distal half; serrula exterior of 17 ligulate plates; movable finger about 0.16 mm. in length.

Palp.—Fig. 36C. Maxilla with numerous acuminate setae and with all except the ventral face moderately granulate; the trochanter, femur, and tibia weakly to moderately granular and with numerous clavate setae, the setae ranging from strongly clavate on the trochanter and femur to weakly clavate on the extensor surface of the tibia; chela weakly granulate on the flexor surface, setae more clavate on the flexor than on the extensor surface; fingers almost smooth and with numerous acuminate setae. Maxilla 0.34 mm. long, 0.24 mm. wide. Trochanter with very globose protuberances, little elevated; pedicle almost as long as wide; 0.34 mm. long, 0.205 mm. wide. Femur with pedicle well separated from the rest of the segment and a little wider than long; flexor margin weakly convex except on the distal one-third; extensor margin a little convex; 0.48 mm. long, 0.21 mm. wide. Tibia with a stout pedicle; flexor margin bulging in the center but flattened beyond; extensor margin flatly convex in the central portion; setae much less clavate on the extensor than on the flexor surface; 0.48 mm. long, 0.22 mm. wide. Chela with pedicle near center of base; extensor margin flatly convex, flexor margin much more convex; fingers slender and gently curved; chela, without pedicle, 0.85 mm. long, 0.31 mm. wide; hand, without pedicle, 0.415 mm. long, 0.3 mm. deep; movable finger 0.455 mm. long. Viewed laterally, fig. 36A, chelal hand fairly stout, pedicle displaced a little toward the ventral side; ventral margin little convex, dorsal margin more convex; basal margin rounded; the fixed finger nearly straight, the movable finger a little curved. Tactile seta as shown in the figure. Fixed chelal finger with a reduced venedens, fig. 36B, and a short vestigial venom duct; nodus ramosus of movable finger between one and two areolar diameters basad from tactile seta *t*; marginal teeth of both fingers contiguous and cusp-bearing, between 30 and 35 in number; three or four internal

and the same number of external accessory setae on each finger.

Legs.—Setae of legs variable; those of the extensor surface of segments chiefly clavate, others subclavate to acuminate; segments apparently smooth. First leg with pars basalis 0.122 mm. deep; pars tibialis with both margins evenly convex, 0.113 mm. deep; entire femur with most setae subclavate to clavate, 0.34 mm. long; tibia stout and very weakly S-shaped, 0.247 mm. long, 0.087 mm. deep; tarsus with setae of extensor surface acuminate, extensor margin nearly straight, flexor margin very weakly convex, deepest at the basal third and tapering a little toward the distal end, 0.27 mm. long, 0.065 mm. deep. Fourth leg with setae of the trochanter, the pars basalis, and the flexor surface of the tarsus acuminate; setae of the extensor surface of the tibia and tarsus strongly clavate; setae of the flexor surface of the pars tibialis and tibia weakly clavate to acuminate; pars basalis 0.145 mm. deep; entire femur with the flexor margin evenly rounded and weakly convex, the extensor margin well rounded and evenly convex, margins of the two femoral parts continuous; entire femur 0.46 mm. long, 0.155 mm. deep; tibia much more slender than that of the first leg and a little S-shaped, 0.365 mm. long, 0.095 mm. deep; tarsus narrowing gradually toward the distal end, 0.305 mm. long, 0.07 mm. deep; a sub tactile clavate seta longer than the other investing setae located toward the distal end of the extensor margin of the tarsus.

Genital Complex.—Posterior margin with setae forming a single row; anterior periculum with about 20 setae irregularly arranged in a group anterior to the genital aperture.

MALE.—The single known male, the allotype, not in a favorable condition or position for study, having been mounted in an unsected condition by Ewing. As near as can be determined, structural details are identical in the two sexes except that the chela is a little stouter and the tactile seta of the movable chelal finger is relatively closer to *t* and farther from *sb* in the male. Measurements secured from the male as follows: carapace 0.65 mm. long, 0.67 mm. deep; palpal trochanter 0.34 mm. long and 0.05 mm. wide; femur 0.49 mm. long, 0.21 mm. wide; tibia 0.48 mm. long, 0.215 mm. deep; chela exclusive of pedicle 0.85 mm. long and 0.32 mm. wide; chelal hand ex-

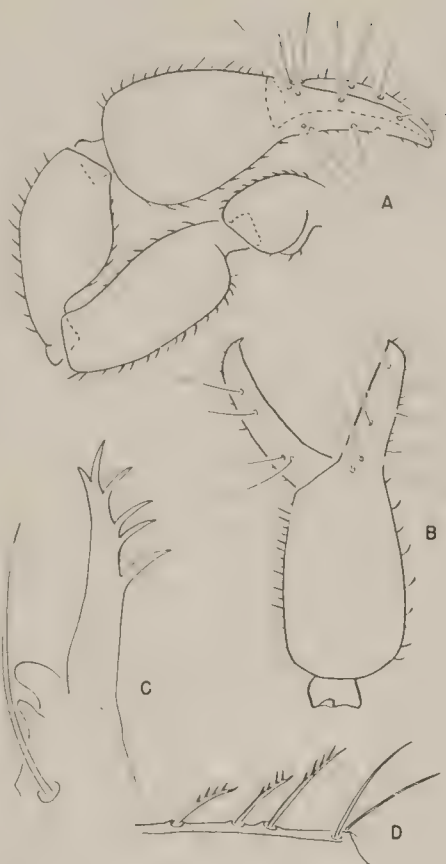


Fig. 37.—*Reginachernes lymphatus*. A, dorsal view of palp, holotype ♀; B, lateral view of chelal hand, allotype ♂; C, tip of movable chelicer of finger, holotype ♀; D, apical setae of extensor surface of tarsus IV, holotype ♀.

clusive of pedicle about 0.4 mm. long, movable finger 0.46 mm. long. Fourth leg with entire femur 0.46 mm. long, 0.15 mm. deep; tibia 0.36 mm. long, 0.09 mm. deep; tarsus 0.31 mm. long and 0.07 mm. deep. Details of genital complex not discernible in specimen.

Holotype, female.—Muncie, Illinois, Sept. 19, 1943, H. H. Ross.

Allotype, male.—Arcola, Illinois, July 21, 1909, H. E. Ewing (mcz).

The holotype was collected from leaf mold and the allotype was secured from beneath the bark of an oak tree.

Reginachernes lymphatus new species

Reginachernes lymphatus, figs. 37A-37D, may be separated from *ewingi* by characters

given in the key. The palp of *lymphatus* has considerable similarity to the palp of *Chelanops corticis* Ewing, as figured by Ewing (1911, fig. 9). Our form, however, differs in many ways from the text description given by Ewing with respect to the cheliceral galea, the investing setae of the palps, and other details. There is a possibility that some of these characters may have been misinterpreted, in which case *lymphatus* may really be *corticis*. To date the type material of *corticis* has not been located; so its identity cannot be established.

FEMALE.—Observations and measurements are based upon the female holotype and one female paratype unless otherwise indicated. Body and legs light brown, palps golden brown; body stout; length of body (four females measured) between 2.4 and 2.6 mm., the holotype with the abdomen contracted measuring only 1.95 mm. Carapace stout; anterior half with rounded margins, posterior portion with sides almost parallel; surface moderately to coarsely granular, appearing more weakly granular on the dorsal surface; setae scattered, fairly numerous, distinctly clavate; posterior transverse furrow much closer to the posterior carapacic margin than to the median furrow; posterior carapacic margin with 10 to 12 clavate setae; eye spots not observed; length of carapace about 0.85 mm., greatest width about 0.75 mm. Tergites of abdomen brown in color, all divided except the eleventh, with the interscutal membranes very rugose; tergites fairly granular; setae clavate, usually seven setae on each scutum of first tergite and eight setae on each scutum of the second tergite, maximum number of setae on any tergal half is 11. Sternites 4 through 10 divided; interscutal spaces striate and rugose; sternal scuta brown in color, marked by scalelike lines; each half-sternite of the fourth abdominal segment with four to six acuminate setae; maximum number of setae on any sternal half is 17. Pleural membranes very rugose; each anterior stigmatic plate with two setae, posterior plate with one; abdomen stout, usually about 1.5 mm. long, about 1 mm. wide.

Chelicera.—Fairly stout; palm of hand with netlike markings; subbasal seta with a few minute terminal and subterminal denticulations; longest flagellar seta unilaterally serrate, the serrations minute and widely spaced; length of chelicera 0.22–0.24 mm., width of base 0.13 mm. Fixed finger slen-

der; lamina exterior well developed and evenly convex; inner margin of apical tooth with three small denticles, inner margin of finger with two strong and two weak denticles near the distal end. Movable finger, fig. 37C, fairly stout; subapical lobe inserted near the base of the apical tooth and much distad from the insertion of the galeal seta; one or two minute denticles on the inner finger margin near the level of the insertion of the galeal seta; galeal seta not reaching to the tip of the galea; galea fairly stout, with six simple and distally acute rami confined to the distal one-half of the galea; serrula exterior of 17 or 18 ligulate plates; length of movable cheliceral finger about 0.19 mm.

Palp.—Fig. 37A. Measurements and ratios of the palpal femur, tibia, and chela (except the depth) given as the range of four individuals (the holotype and three female paratypes), of which two are in alcohol. Stout, fairly deep brown to reddish or golden brown in color; the sides of the maxilla and the entire trochanter and femur moderately to coarsely granular; the flexor surface of the tibia moderately granular; the flexor surface of the chelal hand weakly to moderately granular; setae of the trochanter and the flexor surfaces of the femur and tibia heavy and chiefly clavate; setae of the extensor surface of the femur and tibia less strongly clavate and sometimes paucidenticate; setae of the flexor surface of the chelal hand subclavate, those of the extensor surface paucidenticate; setae of the fingers acuminate. Maxilla about 0.4 mm. long and 0.3 wide. Trochanter in strict dorsal view very stout; subdorsal protuberance rounded and not much elevated; trochanter of female paratype 0.42 mm. long, 0.24 mm. wide. Femur with pedicle little longer than wide; extensor margin of femur very flatly convex, flexor margin weakly convex in the basal two-thirds but weakly concave beyond; measured along the extensor margin 0.63–0.64 mm. long, 0.255–0.27 mm. wide, length 2.35 to 2.5 times the width. Tibia with extensor margin slightly flattened in the central portion; flexor margin bulging and convex except at the extreme distal end where the margin is flattened or very slightly concave; 0.6–0.63 mm. long, 0.28–0.29 mm. wide, length between 2.1 and 2.2 times the width. Chela with margins evenly convex, the flexor margin a little more convex than the extensor; base of hand

rounded; fingers fairly slender and somewhat curved; chela, without pedicle, 0.99–1.02 mm. long, 0.37–0.38 mm. wide, length between 2.65 and 2.75 times the width; chelal hand exclusive of pedicle 0.52–0.55 mm. long, about 0.33 mm. deep (depth determined for the hand of only one female); movable finger 0.5–0.53 mm. long. Viewed laterally, the base of the chelal hand appears rounded, the margins weakly convex, and the pedicle displaced a little toward the ventral side; the fixed finger nearly straight, the movable finger a little curved and appearing weakly granulate on the exterior surface. Tactile setae of chelal fingers as shown for the male, fig. 37*B*; nodus ramosus of movable chelal finger varying from a position about midway between tactile setae *t* and *st* to a position much closer to *st* than to *t*. Each finger with about 40 contiguous, conical, cusp-bearing marginal teeth; accessory teeth somewhat variable, usually 8 to 10 in the external row of each finger and 1 to 4 in the internal row; end of fixed finger with a very poorly developed venedens containing a vestigial duct.

Legs.—Measurements relative to the holotype are followed in parentheses by the corresponding measurements of the mounted female paratype whenever the two show a significant difference. Legs usually light brown in color; femoral parts and tibiae weakly granular, granules not easily observed except on the pars tibialis; setae of the extensor surface of the segments and in part setae of flexor surfaces of femora subclavate to paucidenticulate; setae of the flexor surfaces of the tibia and tarsus acuminate and more numerous. First leg with pars basalis 0.152 (0.16) mm. deep; pars tibialis 0.14 mm. deep; entire femur 0.44 mm. long, length 2.88 (2.75) times the depth; tibia stout, deepest near the distal one-third, 0.3 (0.315) mm. long, 0.102 mm. deep; tarsus tapering a little toward the distal end, subcylindrical, about 0.295 mm. long, 0.065 (0.068) mm. deep. Fourth leg with pars basalis 0.182 (0.175) mm. deep; pars tibialis 0.205 (0.192) mm. deep; femur with extensor margin evenly convex, flexor margin very weakly convex to straight, length of entire femur 0.595 (0.61) mm., length 2.9 (3.17) times the depth; tibia much more slender than in the first leg, flexor margin a little convex, extensor margin straight to a very little concave; tibia 0.46 (0.48) mm. long, 0.12 (0.114) mm.

deep; tarsus subcylindrical but tapering a little toward the distal end, 0.34 (0.35) mm. long, 0.084 mm. deep; the extensor margin of the tarsus with a denticulate pseudotactile seta, fig. 37*D*, longer than the denticulate investing setae and located 0.2–0.22 mm. from the proximal margin of the tarsus.

Genital Complex.—About 12 to 15 marginal setae on the posterior operculum; nearly 20 setae grouped anterior to the aperture on the anterior operculum.

MALE.—Unless otherwise indicated, description and measurements are based upon the male allotype. Body and carapace much as in the female; a few more setae on the fourth sternal halves and a few less on the central sternal halves than in the female; body of allotype 2.4 mm. long, of one paratype 2.15 mm. long; carapace and abdomen as in the female.

Chelicera.—As in the female.

Palp.—Chaetotaxy and sculpturing, as well as the general appearance, much as in the opposite sex except setae may be a little heavier and the palpal femur and chela appear to be a very little stouter. Measurements based on two individuals (one in alcohol), the measurements of the male allotype followed in each instance by the corresponding measurement of the male paratype, whenever a measurement was secured for the latter. Maxilla 0.38 mm. long, about 0.3 mm. wide; trochanter 0.43 mm. long, 0.25 mm. wide; femur measured along the extensor margin 0.64 (0.6) mm. long, 0.27 (0.255) mm. wide; tibia 0.63 (0.6) mm. long, 0.295 (0.285) mm. wide; chela exclusive of pedicle 1.06 (0.97) mm. long, 0.407 (0.38) mm. wide; chelal hand exclusive of pedicle 0.55 (0.51) mm. long, 0.355 mm. deep; movable finger 0.545 (0.51) mm. long. Tactile setae, fig. 37*B*, and teeth of the chelal fingers much as in the female.

Legs.—Essentially as in the female; measurements secured only from the allotype. First leg with pars basalis 0.15 mm. deep, pars tibialis 0.14 mm. deep; entire femur 0.44 mm. long; tibia 0.308 mm. long, 0.103 mm. deep; tarsus 0.285 mm. long, 0.065 mm. deep. Fourth leg with pars basalis 0.164 mm. deep, pars tibialis 0.183 mm. deep; entire femur 0.595 mm. long; tibia 0.465 mm. long, 0.118 mm. deep; tarsus 0.345 mm. long, 0.084 mm. deep; denticulate pseudotactile seta located 0.225 mm. from proximal margin of tarsus.

Genital Complex.—Posterior operculum

with 24 scattered setae, some of which are arranged along the posterior margin, and four smaller setae just posteriad to the posterior rim of the aperture; anterior operculum with 24 scattered setae.

TRITONYMPH.—Unless indicated to the contrary, description is based on one tritonymph paratype. Lighter in color, smaller in size, and with stouter segments than in the adult. Chaetotaxy of the abdomen and carapace much as in the adult but with a slightly smaller number of setae; body about 2 mm. long.

Chelicera.—Much as in the adult except smaller; the denticulations of the subbasal seta almost wanting; galea more slender and the rami confined to about the distal one-third; serrula exterior of 15 or 16 ligulate plates.

Palp.—Chaetotaxy and sculpturing much as in the female, except the setae a little less stout, color lighter; the palpal femur a little stouter but the chela more slender than in the adult. Measurements of the femur, tibia, chela, and movable finger are the ranges secured from measuring three individuals, of which two are unmounted. Femur 0.4–0.41 mm. long, 0.195–0.2 mm. wide; tibia 0.395–0.4 mm. long, 0.205–0.21 mm. wide; chela exclusive of pedicle 0.7–0.73 mm. long, 0.25–0.255 mm. wide; movable finger 0.37–0.39 mm. long; chelal hand exclusive of pedicle in the mounted paratype 0.37 mm. long, 0.35 mm. deep. Movable finger with three tactile setae: *t* a little more than one-third of the finger length from the tip; *b* placed much as in the adult; *st* midway between *t* and *b*; *sb* wanting; *nodus ramosus* about one areolar diameter proximad from the level of tactile seta *t*. Fixed finger with tactile setae much as in the adult except *ist* is wanting and *it* is relatively a little farther from the level of *et*. Each finger with between 25 and 30 marginal teeth; each external row of accessory teeth with three to five teeth, internal row represented by one or two teeth; fixed finger with weakly developed venedens and vestigial duct.

Legs.—Lighter in color, less sclerotic, and with fewer setae than in the adult; segments stouter; tarsi more narrowed distally; fourth tarsus with the denticulate pseudotactile seta as described for the adult. Measurements not secured.

DEUTONYMPH.—Description based on one individual. Smaller, lighter in color, and

with appendages stouter than in the tritonymph; most tergal scuta with five or six clavate setae; anterior stigmatic plate appears to have but one seta; length of body about 1.4 mm.

Chelicera.—Smaller than in the tritonymph; subbasal seta simple; galea with probably three rami, terminal and subterminal in position.

Palp.—Segments much smaller, lighter in color, and with fewer and slightly weaker setae than in the tritonymph; general shape very similar in the tritonymph and the deutonymph. Measurements of one deutonymph follow: femur 0.28 mm. long, 0.145 mm. wide; tibia 0.28 mm. long, 0.15 mm. wide; chela exclusive of pedicle 0.53 mm. long, 0.185 mm. wide; chelal hand exclusive of pedicle 0.275 mm. long, 0.175 mm. deep; movable finger 0.27 mm. long. Viewed laterally, dorsal margin of chelal hand appears much more convex than the ventral margin. Movable finger with two tactile setae; one probably *st*, a little distad from the mid-point of the finger and about one areolar diameter proximad from the level of the *nodus ramosus*; *b* as in the tritonymph. Setae of the fixed finger considerably different from those of the tritonymph; *it* near the mid-point of the finger or a little proximad from the mid-point; *et* about midway between the finger tip and *it*; *est* about as far from the finger base as *et* is from the finger tip; *ib* a little proximad from the level of *isb*; *esb* apparently wanting; *eb* basad from the level of *ib*. Marginal teeth of the chelal fingers much as in the tritonymph except cusps less well developed; accessory teeth wanting except for a single internal accessory tooth near tip of fixed finger.

Legs.—Much like the legs of the tritonymph except less sclerotic, much smaller, and with many segments probably a little stouter. Pseudotactile seta of the fourth pedal tarsus denticulate in the mounted deutonymph.

Holotype, female.—Urbana, Illinois: Brownfield Woods, Oct. 21, 1933, H. H. Ross.

Allotype, male.—Mooseheart, Kane County, Illinois: Sept. 24, 1940, Henry Dybas (CM).

Paratypes.—ILLINOIS. AURORA: Sept. 4, 1939, Henry Dybas, 4 tritonymphs, 2 deutonymphs (CM); April, 1940, 1 ♂, 1 ♀, 2 tritonymphs (CM). MOOSEHEART: same data as for allotype, 2 ♀ (CM).

The holotype was taken from soil-cover mounds in oak-hickory woods.

17. *PSEUDOZAONA* Beier

Pseudozaona Beier (1932c, p. 182; 1933, p. 542). Genotype, by original designation, also monobasic: *Pseudozaona communis* Beier. *Pseudozaona* Beier. Hoff (1947, p. 539).

Carapace longer than wide, with two transverse furrows. Setae of body and palps clothed, usually subclavate to clavate. Flagellum with four setae. Palps slender, figs. 38A, 38C, the pedicle of the femur not well set off from the rest of the segment. The tactile seta *ist* placed distad from *est* on the fixed chelal finger; *st* between *t* and *sb* or a little closer to *t* than to *sb* on the movable chelal finger. Legs moderately slender; tarsus of fourth leg without a tactile seta.

This genus, which has not been reported from Illinois, can be recognized by characteristics given in the key. It contains the genotype, *communis*, from Mexico; *unimicris* (Banks), from Costa Rica; and *mirabilis* (Banks), from the eastern United States, where it has been taken from caves in Kentucky and Virginia. Diagnostic char-

acters are illustrated in figs. 38A-C; a more nearly complete description has been given previously by the writer (Hoff 1946f).

18. *DINOCHEIRUS* Chamberlin

Dinocheirus Chamberlin (1929a, p. 171). Genotype, monobasic: *Dinocheirus tenoch* Chamberlin.

Dinocheirus Chamberlin. Chamberlin (1934, p. 126), Hoff (1947, p. 513).

DIAGNOSIS.—Carapace with two well-developed transverse furrows; usually no eye spots. Cheliceral hand with five setae, the basal seta acuminate, the subbasal seta subterminally denticulate; galea of male commonly less branched than the galea of the female; flagellum of chelicera with four setae. Palps moderately stout; chela of male usually stouter and larger than that of the female; well-developed accessory teeth present on the chelal fingers; nodus ramosus of movable finger between *t* and *st*; *st* closer to *t* than to *sb* and *t* closer to *st* than to the finger tip; *ist* commonly a little distad from *est*, fig. 39B. Tarsus of fourth leg with an acuminate or pseudotactile acuminate seta located distad from the mid-point of the extensor surface and longer than the

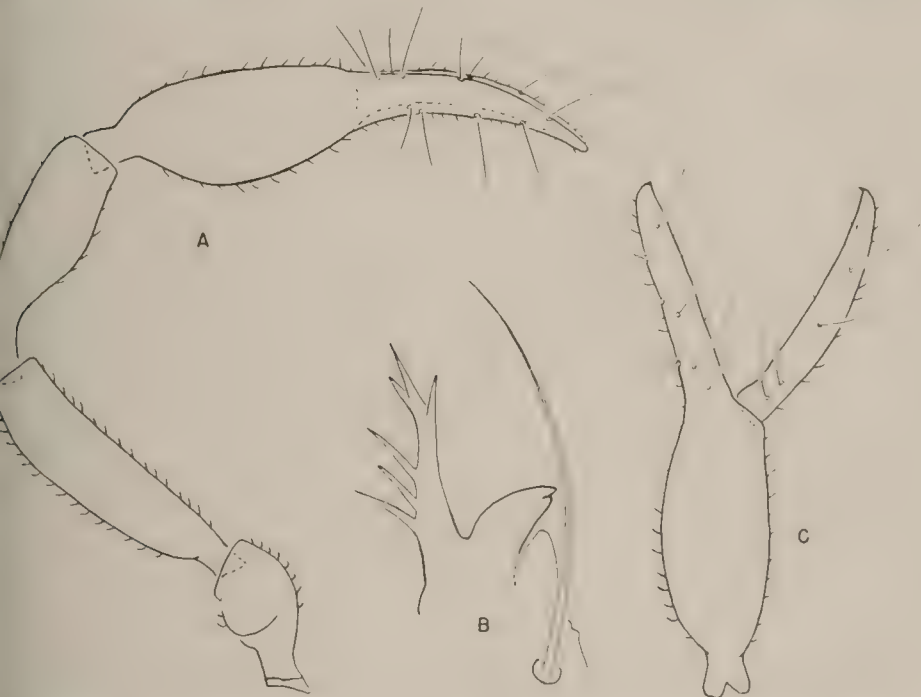


Fig. 38.—*Pseudozaona mirabilis* ♂. A, palp, dorsal view. B, end of movable finger of chelicera; C, chela, lateral view (teeth omitted).

depth of the tarsus. Seminal receptacle of the female paired, very elongate, tubular, with a terminal ovate sac.

Two species have been collected in Illinois. Several others are known from the Atlantic states and from the West and Southwest.

KEY TO SPECIES

- Palpal femur with length more than 0.6 mm.
and more than 2.5 times the width.....
.....**pallidus**
Palpal femur with length less than 0.6 mm.
and less than 2.5 times the width.....**solus**

Dinocheirus pallidus (Banks) new combination

Chernes pallidus Banks (1890, p. 152).

Hesperochernes pallidus (Banks). Hoff (1947, p. 509).

Ewing (1911) listed *Chelanops pallidus* from Arcola and from Marshall, Illinois. A study of some of the specimens assigned by Ewing to this species indicates an incorrect determination, which is also evident when his figure (Ewing 1911, fig. 11) is compared with the lectotype of *pallidus* at the Museum of Comparative Zoology. Ewing's available specimens of *pallidus* are really *Parachernes squarrosus* new species, as noted under this latter species.

Diagnostic characters for *pallidus* are given in fig. 39. The male has not been described previously. Three specimens of this sex were taken in an Arkansas collection along with a female that agrees closely with the lectotype at the Museum of Comparative Zoology.

MALE.—Description and measurements based on four males, one from Illinois and three from Arkansas. Body fairly stout, yellowish to light brown in color; palps reddish-brown; body length 2.55–2.75 mm. Carapace granular; setae clavate and fairly numerous; anterior half of carapace rounded, posterior portion of sides subparallel; posterior margin with 12 to 15 irregularly placed marginal setae; no eye spots; carapace 0.88–0.96 mm. long, 0.6–0.8 mm. wide near the center; posterior width a little less than the greatest width. Tergites of abdomen except the eleventh divided but first tergite sometimes very weakly divided; setae clavate; each first tergal scutum with 9 or 10 setae, central tergal halves with as many as 14 setae; tergal scuta moderately granular. Sternites 4 through 10 divided, marked by scalelike markings; each half-sternite 4 with four setae; maximum number of setae

on any sternal half about 12, usually somewhat less; setae acuminate to subacuminate and paucidenticulate. Pleural membranes with fine wavy striations; each stigmatic plate with one or two (rarely three) setae, somewhat variable; abdomen 1.65–1.8 mm. long, about two-thirds as wide as long.

Chelicera.—Fairly stout, deep yellow in color; palm of hand with a few netlike markings; subbasal seta denticulate, basal seta acuminate; length of chelicera 0.24–0.25 mm.; width of base 0.135–0.165 mm., movable finger 0.2–0.23 mm. long. Fixed finger slender; two or three small denticles on the inner margin of the apical tooth and four or five denticles on the inner margin of the finger near the distal end. Movable finger, fig. 39C, little curved; apical tooth often weakly bicuspid; subapical lobe weakly bicuspid or tricuspid, often a weak denticle on the finger margin near the insertion of the galeal seta; gelea slender and with five or six acutely pointed, short rami confined to the distal one-third; galeal seta not reaching to the level of the tip of the galea; serrula exterior of 17 or 18 ligulate plates.

Palp.—Fig. 39A. Moderately stout; granular except the face of the maxilla, the extensor surface of the tibia and the chelal hand, and the fingers; setae of maxilla acuminate; setae of the trochanter and femur subclavate and multidenticulate, those of the tibia multidenticulate but somewhat slender and especially on the extensor surface not subclavate; setae of the chelal hand weakly multidenticulate to paucidenticulate, those of the fingers acuminate. Maxilla 0.45–0.53 mm. long, 0.27–0.32 mm. wide. Trochanter with a stout subdorsal protuberance; length 0.38–0.45 mm., 1.4 to 1.6 times the width. Femur with pedicle about as long as wide; extensor surface of femur weakly and somewhat flatly convex; flexor surface weakly convex except a little concave near the distal end; 0.77–0.88 mm. long, 0.27–0.31 mm. wide; length 2.75 to 3.25 times the width. Tibia with extensor margin somewhat flatly convex; flexor margin convex near the center but somewhat concave beyond; 0.76–0.8 mm. long, 0.29–0.34 mm. wide; length 2.45 to 2.65 times the width. Chela as viewed from the dorsum with the extensor, flexor, and basal margins more or less evenly convex; in general the chelal hand is elongate-oval, tapering somewhat toward the base of the fingers, and widest in the basal half; chelal fingers

slender, gently and evenly curved; chela exclusive of pedicle 1.22–1.36 mm. long, 0.43–0.52 mm. wide, length 2.6 to 3.0 times the width; chelal hand exclusive of pedicle

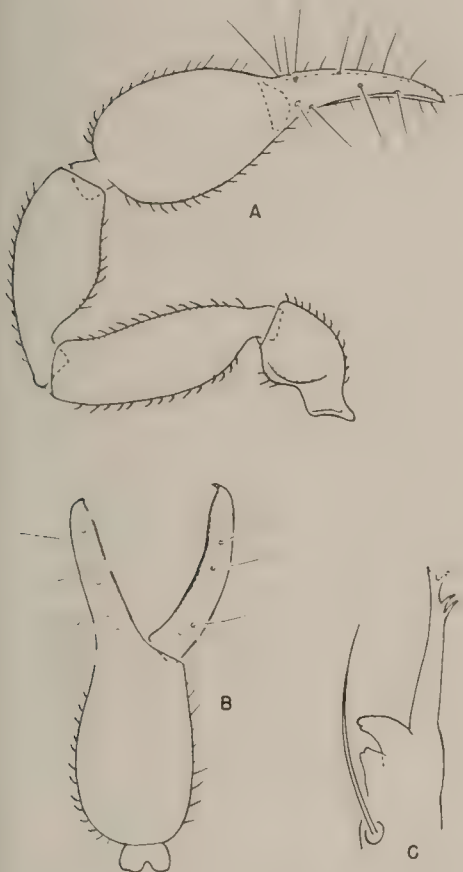


Fig. 39.—*Dinocheirus pallidus* ♂. A, dorsal view of palp; B, lateral view of chela; C, end of movable cheliceral finger.

0.64–0.69 mm. long, 0.4–0.52 mm. deep, usually 4.5 mm. or less; movable finger between 0.63 and 0.72 mm. long, usually 0.7 mm. or more. Viewed laterally, fig. 39B, chelal hand fairly stout, extensor and flexor margins moderately convex but hand tapering little toward base of fingers; basal margin flatly convex, with the pedicle displaced somewhat toward the ventral side; movable finger markedly convex, especially near the center; fixed finger variable, either nearly straight or with the inner margin convex and the outer margin distinctly concave;

fingers gapping when closed. Tactile setae as shown in the figure. Fixed finger with a vestigial venedens and a short nonfunctional venom duct. Marginal teeth of chelal fingers contiguous and cuspid, between 35 and 45 on each finger; each finger usually with two (occasionally only one) to four internal and six to eight external accessory teeth. Nodus ramosus of movable chelal finger located between tactile seta *t* and *st*, usually much closer to the latter than to the former.

Legs.—Legs slender; setae multidenticulate to paucidenticulate on the extensor surface of segments, paucidenticulate on the flexor surface of segments except acuminate on the flexor surface of the tarsi; femora and tibiae weakly granular or sculptured by netlike markings. First leg with trochanter 0.16–0.18 mm. long, length 1.1 to 1.13 times the width; pars basalis 0.16–0.18 mm. deep; pars tibialis 0.145–0.16 mm. deep, with both margins very weakly convex; entire femur 0.56–0.65 mm. long, length 3.1 to 3.6 times the depth; tibia slender, flexor margin weakly convex, 0.41–0.49 mm. long, 0.1–0.11 mm. deep, length 3.9 to 4.5 times the depth, length usually 4.3 or more times the depth; tarsus very slender, subcylindrical, tapering a little toward the distal end, 0.4–0.45 mm. long, 0.065–0.075 mm. deep, length 5.7 to 6.4 times the depth. Fourth leg with pars basalis 0.2–0.21 mm. deep; pars tibialis 0.23–0.24 mm. deep; entire femur with evenly convex extensor margin, flexor margin virtually straight except at the ends, 0.72–0.82 mm. long, length 3.0 to 3.4 times the depth; tibia with weakly convex flexor margin, extensor margin nearly straight except at the basal end, 0.6–0.7 mm. long, 0.13–0.145 mm. deep, length 4.5 to 4.9 times the depth; tarsus tapering a little toward the distal end, 0.45–0.50 mm. long, 0.08–0.09 mm. deep, length 5.35 to 5.75 times the depth; short tactile seta on the extensor surface 0.32–0.37 mm. from the proximal end of the tarsus.

Genital Complex.—Posterior operculum with about 25 setae, many of which form an irregular marginal row, and with 6 to 8 setae along the very posterior rim of the aperture; anterior operculum very setaceous, with between 50 and 60 setae more or less scattered over the face of the operculum.

FEMALE.—The two available females, one from Illinois and one from Arkansas, are

essentially like the male and also very similar in detail to the female lectotype previously described (Hoff 1947). Some of the minor discrepancies noticed between the present females and the lectotype can be attributed to the poorly preserved and somewhat broken condition of the lectotype. None of the differences are of sufficient value to justify even subspecific segregation. Measurements are given to show some of the species variations that occur. The measurement of the single available female from Illinois is followed in each instance by the corresponding measurement of the female from Arkansas. Female length 3.35 (2.98) mm.; carapace 1.1 (1.01) mm. long, 0.83 (0.675) mm. wide; abdomen about 2.3 (1.86) mm. long, 1.8 (1.25) mm. wide; chelicera 0.26 (0.255) mm. long, 0.155 (0.145) mm. wide across the base, movable finger 0.21 (0.21) mm. long. Palp with maxilla 0.51 (0.51) mm. long, 0.35 (0.34) mm. wide; trochanter 0.51 (0.48) mm. long, 0.3 (0.32) mm. wide; femur measured along the extensor margin 0.88 (0.88) mm. long, greatest over-all length 0.94 (0.95) mm., width 0.305 (0.29) mm.; tibia 0.84 (0.785) mm. long, 0.335 (0.315) mm. wide; chela exclusive of pedicle 1.44 (1.44) mm. long, 0.52 (0.495) mm. wide; chelal hand exclusive of pedicle 0.75 (0.735) mm. long, 0.53 (0.485) mm. deep; movable finger 0.78 (0.77) mm. long. First leg with pars basalis 0.182 (0.178) mm. deep; pars tibialis 0.155 (0.152) mm. deep; entire femur 0.65 (0.625) mm. long; tibia 0.48 (0.465) mm. long, 0.106 (0.103) mm. deep; tarsus 0.45 (0.46) mm. long, 0.068 (0.076) mm. deep. Fourth leg with pars basalis 0.228 (0.225) mm. deep; pars tibialis 0.25 (0.246) mm. deep; entire femur 0.85 (0.83) mm. long; tibia 0.68 (0.69) mm. long, 0.136 (0.133) mm. deep; tarsus 0.49 (0.495) mm. long, 0.091 (0.092) mm. deep; tactile seta 0.34 (0.38) mm. from the proximal margin of the tarsus.

TRITONYMPH.—Very similar in most ways to the adult but lighter in color, much smaller in size, and with some segments, especially those of the legs, stouter. Movable chelal finger with three tactile setae: *h* (or *sb*?) wanting; *t* a little distad from the mid-point of the finger; *st* about as far from the finger base as *t* is from the tip; *sb* (or *b*?) as in the adult; *nodus ramosus* a little proximad from the level of tactile seta *t*. Fixed finger with tactile setae much

as in the adult except *ist* is wanting. Important measurements of the tritonymph are given here. Body about 2.45 mm. long; carapace 0.78 mm. long, 0.58 mm. wide. Chelicera 0.22 mm. long, 0.13 wide; movable finger 0.175 mm. long. Palp with the trochanter 0.32 mm. long, 0.21 mm. wide; femur 0.59 mm. long, 0.225 mm. wide; tibia 0.55 mm. long, 0.25 mm. wide; chela exclusive of pedicle 1.03 mm. long, 0.345 mm. wide; chelal hand exclusive of pedicle 0.53 mm. long, 0.35 mm. deep; movable finger 0.54 mm. long. First leg with entire femur 0.43 mm. long, depth across pars basalis 0.152 mm.; tibia 0.308 mm. long, 0.087 mm. deep; tarsus 0.34 mm. long, 0.065 mm. deep. Fourth leg with entire femur 0.61 mm. long, 0.192 mm. deep across the pars tibialis; tibia 0.48 mm. long, 0.114 mm. deep; tarsus 0.38 mm. long, 0.084 mm. deep.

DISTRIBUTION.—This species, originally described from Ithaca, New York, has been taken in two collections from northern Illinois. In addition, three males, one female and one tritonymph were secured by M. W. Sanderson on April 13, 1940, at Lake Wedington Wildlife Area, Washington County, Arkansas.

The Illinois collection from Magnolia came from a decayed log, and the Arkansas specimens were taken from debris in a hollow tree on a wooded hillside.

Illinois Records.—A single male was taken in a collection made by Henry Dybas at Palos Park, Cook County, Illinois, on May 16, 1943, and a single female was taken at Magnolia, Putnam County, Illinois on March 23, 1944, by H. H. Ross.

Dinocheirus solus new species

Specimens of *Dinocheirus solus*, figs. 40A, 40B, differ from those of many species of the genus *Dinocheirus* by their much smaller size. This new species appears to be closely related by size and general structure to *dorsalis* (Banks), from which it is readily separated by small differences in the shape of some of the palpal segments, the length and position of the tactile seta of the fourth pedal tarsus, and numerous other details.

MALE.—Body ovate, fairly stout; yellow to yellowish-brown in color, with the palps a deeper golden brown; length of body 2. mm. Carapace rounded anteriorly, sides convex; widest across the center; furrow well marked; eyes apparently wanting; posterior carapacic margin with 12 setae; al-

of carapace weakly to strongly clavate; surface of carapace moderately granular, dorsal surface virtually smooth; length of carapace 3 mm., greatest width 0.7 mm., posterior width 0.66 mm. Tergites of abdomen weakly granular and with scalelike markings, all divided except the last; intertergal spaces smooth; setae of tergites clavate and with as many as 12 setae on some of the central tergal halves. Sternites 4 to 10 inclusive divided; fourth sternal halves each with four or five setae, central sternal halves each with 11 or 12 setae; all setae of sternites uninate; sternites with scalelike sculpturing; pleural membranes striated and rugose; abdomen about 1.35 mm. long, 1.12 mm. wide.

Chelicera.—Base fairly stout, fingers relatively slender and slightly curved; subbasal margin subterminally denticulate, basal setae uninate; length of chelicera 0.2 mm., length of base 0.125 mm. Fixed finger a little curved, with five or six weakly developed teeth on the distal inner margin in addition to three denticles on the inner surface of the apical tooth. Movable finger nearly straight; subapical lobe not especially well developed; apical tooth terminally serrate and bicuspid; galea slender and long, with five weakly developed and short terminal and subterminal rami; serrula anterior of 17 to 18 plates; movable finger 0.75 mm. long.

Palp.—Fig. 40A. Fairly stout; the lateral surface of the maxilla, the extensor surface of the trochanter, and the flexor surfaces of the femur and tibia coarsely to moderately granular; other surfaces very weakly annulate to smooth; setae acuminate on maxilla; setae of the trochanter, femur, and tibia somewhat stout and multidenticulate to paucidenticulate; setae stouter on femur and the trochanter than elsewhere; chelal hand with setae chiefly paucidenticulate; acuminate setae on the fingers. Maxilla 0.37 mm. long, 0.27 mm. wide. Trochanter with the flexor, or inner margin, moderately convex; 0.32 long, 0.21 mm. wide. Femur moderately stout to stout, 0.6 mm. long, 0.235 mm. wide; outer margin convex, more convex near the ends than the center; inner margin weakly convex the basal two-thirds but a little concave the distal one-third; the pedicle about as long as wide, well set off from the rest of the segment. Tibia with outer margin flatly rounded, inner margin bulging, but slightly

concave distad from the center; pedicle stout; 0.56 mm. long, 0.245 mm. wide. Chela with outer and inner margins more or less evenly convex, the outer a little less convex than the inner; pedicle near the center of the base; fingers slender, curved, well set off from hand; chela, pedicle excluded, 0.9 mm.

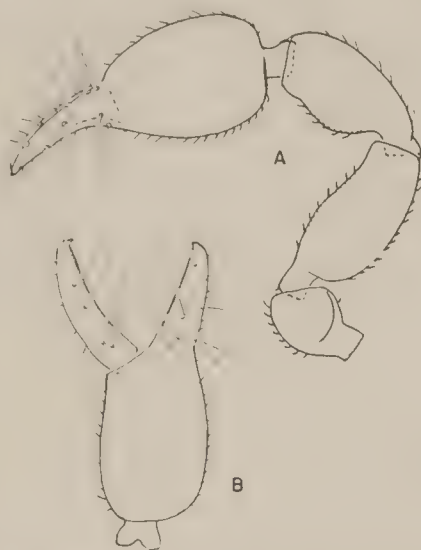


Fig. 40.—*Dinocheirus solus*, holotype ♂. A, dorsal view of palp; B, lateral view of chela.

long, 0.37 mm. wide; chelal hand 0.495 mm. long, 0.34 mm. deep; movable finger of chela 0.46 mm. long. From the side, hand, fig. 40B, appears somewhat quadrangular in general outline; pedicle displaced far toward the ventral side; ventral margin weakly convex, dorsal margin more convex; fingers moderately stout, the fixed finger nearly straight, the movable finger gently curved. Each finger with about 40 marginal teeth, conical and with well-developed cusps at the distal end of the row but rounded and acuspid at the proximal end of the row; each finger with five external accessory teeth; movable finger with three, fixed finger with two, internal accessory teeth. Nodus ramosus of movable finger located just distad from the level of tactile seta *st*. Fixed finger with a vestigial venedens and a short vestigial venom duct.

Legs.—Somewhat slender; yellow in color; pars tibialis and flexor surface of tibia of first leg weakly granular, otherwise pedal segments smooth; setae of the extensor surface of most segments paucidenticulate, slender, not clavate; setae of the flexor sur-

face of segments chiefly acuminate. First leg with pars basalis 0.133 mm. deep; pars tibialis with both margins evenly convex, 0.114 mm. deep; entire femur 0.43 mm. long, 0.133 mm. deep; tibia with outer margin distinctly but weakly S-shaped, flexor

the extensor surface 0.25 mm. from the proximal margin of the tarsus.

Genital Complex.—Posterior operculum with 17 irregularly placed setae on the face of the operculum and along the posterior margin and with five setae on the posterior rim of the genital aperture; anterior operculum with 31 irregularly placed setae, of which the 4 medial ones are much longer and stouter than the others.

Holotype, male.—Rockford, Winnebago County, Illinois: taken from moist wheat stubble, June 12, 1944, C. L. Remington.

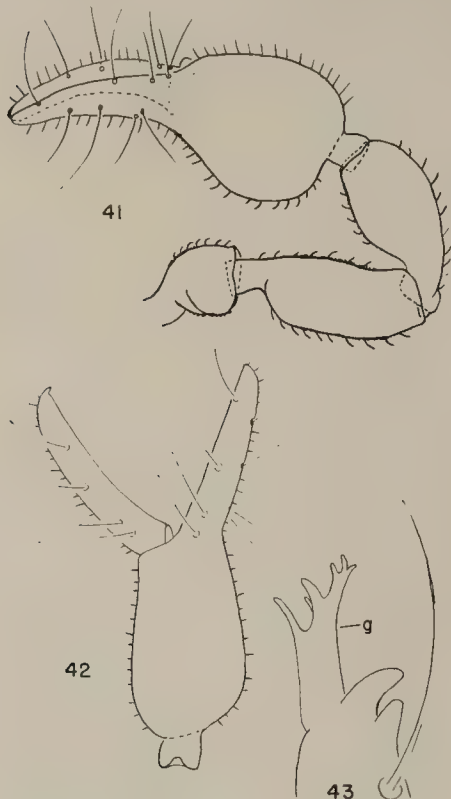


Fig. 41.—*Hesperochnes canadensis* ♂. Dorsal view of palp.

Fig. 42.—*Hesperochnes sanborni* ♂. Chela, lateral view (teeth omitted).

Fig. 43.—*Hesperochnes sanborni* ♂. Tip of movable finger of chelicera; *g*, galca.

margin convex, 0.342 mm. long, 0.088 mm. deep; tarsus tapering very little toward the distal end, 0.315 mm. long, 0.061 mm. deep. Fourth leg with pars basalis 0.14 mm. deep, pars tibialis 0.151 mm. deep; entire femur with flexor margin nearly straight, extensor margin flatly convex, 0.545 mm. long, 0.151 mm. deep; tibia slender, extensor margin very weakly S-shaped, flexor margin weakly convex, 0.46 mm. long, 0.097 mm. deep; tarsus subcylindrical, tapering very little toward the distal end, 0.355 mm. long, 0.07 mm. deep; a short tactile seta located on

19. *HESPEROCHERNES* Chamberlin

Hesperochnes Chamberlin (1924, p. 89)

Genotype, monobasic: *Hesperochnes laur* Chamberlin.

Hesperochnes Chamberlin. Beier (1932c, 174).

Cephalothorax clearly longer than wide; carapace granular with two transverse carapace furrows. Tergites divided, granular. Palps stout, femur with well-defined pedicel. Setae of body and palps usually lightly, but clearly, clavate. Flagellum with four setae; setae *b* and *sb* of hand of chelicera thickened and denticulate. The sensory seta *ist* of the fixed chelal finger is distad from *est*; *st* of the movable chelal finger is found nearer to *t* than to *sb*. The tarsus of the fourth leg is without a true sensory seta, although a short-toothed pseudotactile seta may be present.

This is a common North American genus and is represented by a number of species from the United States, Mexico, and Canada. *H. unicolor* (Banks) has been described from Austin, Texas. Diagnostic characters are illustrated in figs. 41, 42, 43.

20. *ACUMINOCHERNES* new genus

DIAGNOSIS.—Chelicera with both tactile setae *b* and *sb* smooth and acuminate; flagellum with four setae. Palps stout, setae chiefly subclavate to clavate; some sexual dimorphism shown in palps; tactile seta *st* nearer to *t* than to *sb*; tactile seta *ist* distad from *est*, fig. 44D. Fourth leg with a tactile seta distad from the mid-point of the tarsus. Seminal receptacle of female in the form of a long slender tubule terminating in a closed bulb or sac.

Genotype.—*Hesperochnes crassopalpus* Hoff.

A very distinctive characteristic of the genus is the acuminate nature of both the

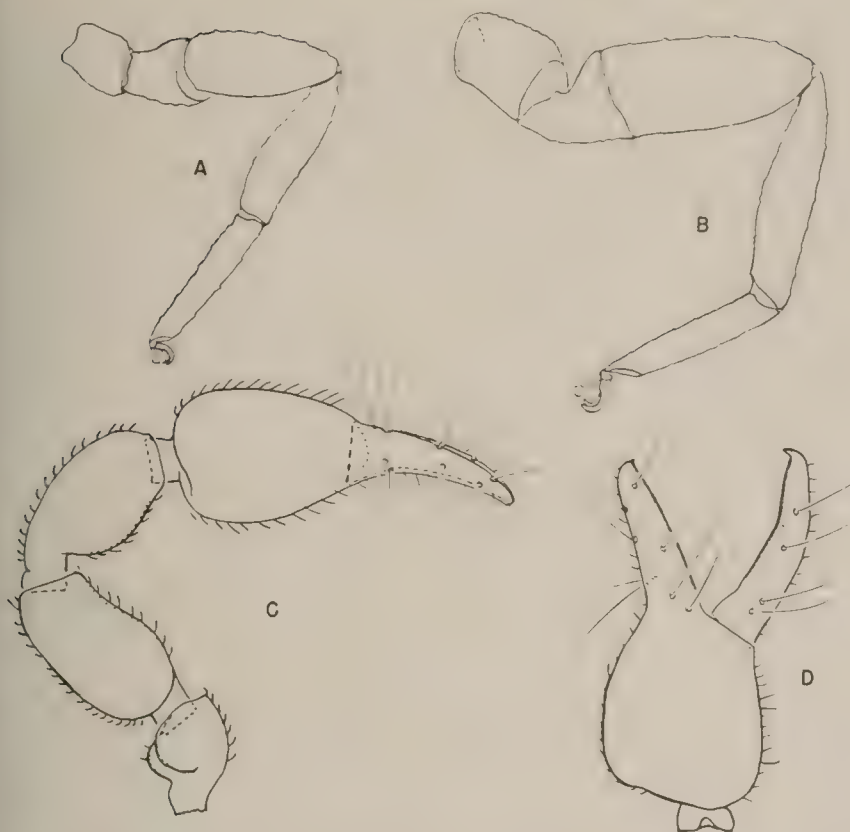


Fig. 44.—*Acuminochernes crassopalpus*. A, right leg I, ♀; B, right leg IV, ♀; C, dorsal view of palp, ♀; D, lateral view of chela, ♂.

basal and subbasal setae of the base of the palpal segments. Only one species, the genotype, is known.

Acuminochernes crassopalpus (Hoff)
new combination

Esperochernes crassopalpus Hoff (1945a, p. 43).

Since the present species has been described in detail in a previous publication (Hoff 1945a), only measurements of the palpal segments and illustrations of chela and palp, figs. 44D, 44C, are given here. The members of this species may be recognized by generic characteristics given in the key.

MALE.—The following pertinent measurements are expressed as the limits of range for nine individuals. Body length 1.8–2.1 mm. Palpal femur 0.56–0.61 mm. long, 0.265–0.295 mm. wide, length 2.0 to 2.1 times the width; tibia 0.56–0.61 mm. long,

0.26–0.3 mm. wide, length 2.0 to 2.2 times the width; palpal chela without pedicle 0.96–1.05 mm. long, 0.425–0.49 mm. wide, length 2.14 to 2.3 times the width; chelal hand 0.43–0.52 mm. deep, 0.48–0.52 mm. long exclusive of pedicle; movable chelal finger 0.53–0.59 mm. long.

FEMALE.—The following measurements are given as the range of six females. Body length 2.0–2.35 mm. Palps with femur 0.57–0.62 mm. long, 0.255–0.27 mm. wide, length 2.2 to 2.3 times the width; tibia 0.56–0.62 mm. long, 0.255–0.28 mm. wide, length 2.15 to 2.22 times the width; chela exclusive of pedicle 0.98–1.05 mm. long, 0.38–0.41 mm. wide, length 2.5 to 2.6 times the width; chelal hand exclusive of pedicle 0.49–0.54 mm. long, 0.375–0.425 mm. deep; movable finger 0.51–0.54 mm. long.

DISTRIBUTION.—This species, which was previously reported only from Arkansas, has been taken in eight collections in north-cen-

tral to southern Illinois. In addition, it was taken from pack-rat nests at Lawrence, Kansas, by R. H. Beamer of the University of Kansas.

Hesperochnes crassopalpus often occurs in great numbers in a collection, although on some occasions it is taken singly. Of the five Illinois collections bearing habitat data, three were secured from debris in hollow trees, one was made from a decayed log, and one came from the stomach of a red-bellied woodpecker.

Illinois Records.—CACHE: April 19, 1944, Ross & Sanderson, 4♂. EDGEWOOD: grass pile, July 25, 1947, Sanderson & Stannard, 7♀, 10♂. GILLESPIE: Aug. 30, 1944, Clarence & Marie Goodnight, 1♀. HERRIN: July 8, 1944, W. Snow, 1 tritonymph (ws). LAWRENCE: Aug. 25, 1944, W. Snow, 1 specimen. MAGNOLIA: March 23, 1944, Ross, great numbers of ♂♂, ♀♀, and nymphs. THOMASBORO: in corn mash, Nov. 10, 1947, Cooper, 1♀, 5 immatures. URBANA: Nov. 12, 1934, A. C. Toumey, 1♀ (HJV).

21. MIROCHERNES Beier

Mirochernes Beier (1930b, p. 216; 1932c, p. 182). Genotype, by original designation and monobasic: *Chelanops dentatus* Banks.

DIAGNOSIS.—Chelicera with flagellum of four setae; seta *b* of base of chelicera acuminate, seta *sb* denticulate; usually two acute denticles on the inner margin of the movable finger near the level of the insertion of the galeal seta. Palps stout, the chela of the male with an internal hooklike ornament on the hand, fig. 45C; sexual dimorphism marked in the palps; setae subclavate to clavate; tactile seta *st* nearer to *t* than to *sb*; tactile seta *ist* distad from *est*, fig. 45A. Fourth leg with tactile seta distad from the mid-point of the tarsus. Female with seminal receptacle consisting of a long tubule with a saclike bulb at the end.

The generic diagnosis has been amended above to include the tactile seta on the tarsus of the fourth leg. Previously, the tactile seta was reported as wanting (Beier 1932c, Hoff 1947). The tactile seta apparently had been broken from the fourth pedal tarsus of the male lectotype previously examined by the present writer (Hoff 1947) and its presence was, as a result, not reported.

Males of this genus are easily recognized by the unusual modification of the inner surface of the chelal hand. At the present time

characters have not been found for the accurate recognition of females of this genus. The genus contains only the genotype.

Mirochernes dentatus (Banks)

Chelanops dentatus Banks (1895, p. 6).

Mirochernes dentatus (Banks). Beier (1930b, p. 216, but not pp. 217–218, fig. 14; 1932c, p. 182). Hoff (1947, p. 502).

Chernes dentatus (Banks). Chamberlin (1931a, p. 124).

The male of this species is easily recognized by the toothlike projection on the chelal hand, fig. 45C. From related Illinois pseudoscorpions the females may be differentiated by characters given in the key. The female is described here in considerable detail, since, up to the present time, this sex has been undescribed. The females of this species appear to be much more abundant than the males. In some collections, usually mixed with specimens of other species, are nymphs probably of this species. However, since it is impossible to state with certainty that the nymphs are of *dentatus*, they are not described here.

FEMALE.—Measurements given represent the range of eight females. Body and legs light brown in color; palps dark reddish-brown; legs moderately slender, palps stout; body fairly stout, 2.2–3.15 mm. long. Carapace darker and more red in color than the abdomen; transverse furrows well marked; no eye spots; anterior portion of carapace rounded, sides convex; greatest width near the center, slightly narrower across the posterior margin; surface moderately to coarsely granular; setae distinctly clavate, usually 12 setae along the posterior carapacic margin; carapace 0.82–0.99 mm. long, greatest width 0.67–0.85 mm., posterior width 0.64–0.82 mm. Abdomen ovate in general outline; tergites except the eleventh divided; interscutal spaces mostly wide and conspicuously granulate; each first half-tergite with six or seven setae; central tergal halves with as many as 10 setae, all clavate; surface of tergal scuta weakly to moderately granular. Sternites very weakly sculptured, sternites 4 through 10 divided; each fourth half-sternite with three or four setae, central tergal halves with as many as 14 setae, all acuminate; interscutal spaces wide and very weakly sculptured, striate to granulate. Each anterior stigmatic plate with three setae, each posterior plate with one; pleural membranes very rugose and papillose; abdomen 1.4–2.2 mm. long, greatest width 1.05–1.6 mm.

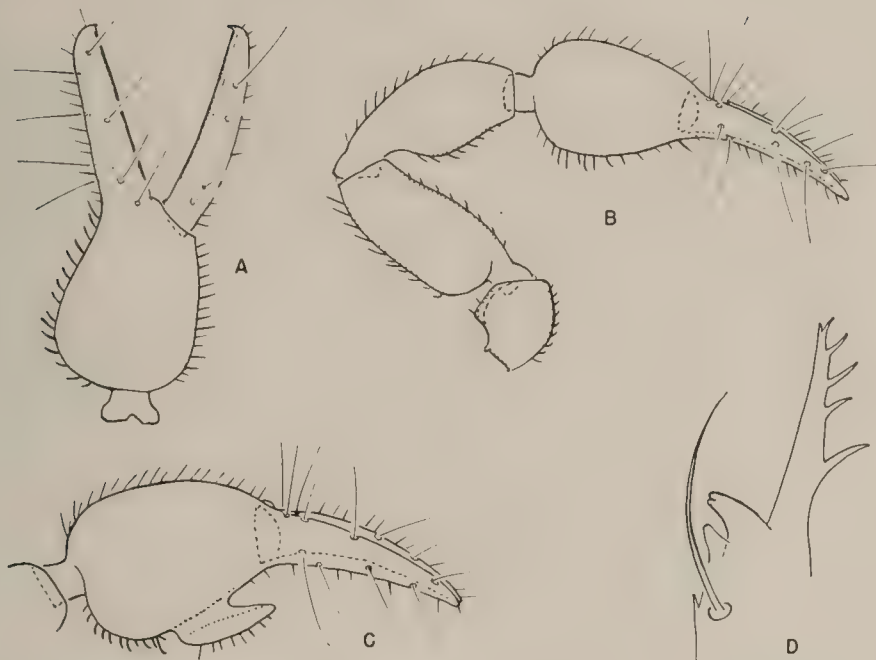


Fig. 45.—*Mirochernes dentatus*. A, lateral view of chela, ♀; B, dorsal view of palp, ♀; C, dorsal view of chela, ♂; D, tip of movable cheliceral finger, ♀.

Chelicera.—Fairly stout, yellow in color; exterior aspect of base of hand sculptured with netlike markings; subbasal seta terminally and subterminally denticulate, basal seta acuminate; chelicera between 0.25 and 0.3 mm. long, width of base 0.145–0.17 mm., length of movable finger 0.21–0.25 mm. Fixed finger with three denticles on the inner surface of the apical tooth and usually two large and three small denticles on the inner finger margin; lamina exterior well developed and extended as a keel along the base of the chelicera; all except the distal four plates of the serrula interior fused into a velum. Movable finger, fig. 45D, only a little curved; subapical lobe large; one or two acute but small denticles present on the inner finger margin near the level of the insertion of the galeal seta; serrula exterior of 18 to 19 plates; galeal seta reaching only about half way to the tip of the galea; galea with usually six terminal and lateral rami, all simple and arranged along little more than the terminal one-half of the galea.

Palp.—Fig. 45B. Surface moderately granular on trochanter and femur, tibia weakly granular except smooth on the extensor surface, the ventral face of the max-

illa and most of the chela virtually smooth; setae of maxilla acuminate, setae of the trochanter and femur subclavate, setae of the flexor surface of the tibia and chelal hand multidenticulate while those of the extensor surface of the tibia and chelal hand are paucidenticulate; setae of the fingers acuminate. Maxilla 0.43–0.51 mm. long, 0.27–0.35 mm. wide, length 1.4 to 1.6 times the width. Trochanter stout, with two well-rounded protuberances; 0.435–0.51 mm. long, 0.24–0.3 mm. wide, length 1.65 to 1.82 times the width. Femur with a cylindrical pedicle, about as long as wide; femur enlarged suddenly beyond the pedicle and slightly narrowed toward the distal end; extensor margin flatly convex in the central portion; flexor margin slightly S-shaped; femur widest near the center; femur along the extensor margin 0.6–0.75 mm. long, 0.26–0.325 mm. wide, length 2.27 to 2.34 times the width. Tibia with pedicle larger than that of the femur and about as long as wide; flexor margin rounded and bulging except flattened or a little concave near the distal end; extensor margin flatly convex except in the terminal one-third; 0.61–0.8 mm. long, 0.27–0.34 mm. wide, length

2.17 to 2.43 times the width. Chela with hand stout, fingers slender and gently curved; both extensor and flexor margins of chelal hand convex, the flexor much more so than the extensor; hand tapering rapidly toward the fingers; pedicle displaced toward the extensor side of the hand; chela exclusive of pedicle 1.07–1.33 long, 0.365–0.465 mm. wide, length 2.6 to 3.0 times the width; chelal hand exclusive of pedicle 0.48–0.6 mm. long, 0.38–0.475 mm. deep; movable chelal finger 0.625–0.78 mm. long. From the side, chelal hand, fig. 45*A*, appears stout; pedicle displaced far toward the ventral side; fixed finger nearly straight, movable finger usually a little curved. Marginal teeth of chelal fingers conical, contiguous, and with well-defined cusps; usually 50 to 60 marginal teeth on each finger, with slightly more on the fixed than on the movable finger; accessory teeth variable, usually two to four internal accessory teeth and six to eight external accessory teeth. Nodus ramosus of movable finger usually very near the level of tactile seta *st*. Tactile setae of chelal fingers as shown in the figure.

Legs.—Yellow in color; setae of the flexor surface of segments (except pars tibialis of fourth leg) chiefly acuminate, fairly long and numerous; setae of the extensor surface multidenticulate to paucidenticulate; surface of segments smooth except very weakly granular on the femoral parts of the fourth leg and sometimes on the femur of the first leg. First leg with pars basalis 0.16–0.197 mm. deep; pars tibialis slender, extensor margin weakly curved, flexor margin nearly straight to very weakly curved, 0.129–0.155 mm. deep; entire femur 0.48–0.61 mm. long, length 2.98 to 3.28 times the depth; tibia very weakly S-shaped, 0.36–0.46 mm. long, 0.093–0.114 mm. deep, length 3.85 to 4.2 times the depth; tarsus very slender, tapering a little toward the distal end, 0.37–0.45 mm. long, 0.06–0.072 mm. deep, length 5.6 to 6.6 times the depth. Fourth leg with pars basalis 0.175–0.212 mm. deep; pars tibialis 0.188–0.225 mm. deep; entire femur somewhat slender, extensor margin evenly but not strongly convex, flexor margin nearly straight, 0.63–0.8 mm. long, length 3.26 to 3.55 times the depth; tibia S-shaped with the extensor margin markedly concave in the distal two-thirds, 0.5–0.645 mm. long, 0.114–0.133 mm. deep, length 4.35 to 4.85 times the depth; tarsus tapering a little toward the distal end, 0.43–0.53 mm. long,

0.076–0.088 mm. deep, length 5.5 to 6.6 times the depth; tactile seta present on tarsus and located about two-thirds of segment length from the proximal margin of the segment, seta short and easily broken.

Genital Complex.—Usually about 10 setae along the posterior margin of the posterior operculum and 18 to 22 setae scattered on the anterior operculum. Seminal receptacle with surface of bulb at end of tubule rugose or wrinkled.

MALE.—Description based on two Illinois males; the measurements of one are given in parentheses following the corresponding measurements of the other. Body, appendages, and most details as in the female. Tactile chela, fig. 45*C*, is much stouter than in the female and bears a hooklike appendage on the subflexor surface. Body length 2.3 (2.2) mm.; carapace 0.97 (0.88) mm. long, 0.77 (0.77) mm. wide; cheliceral finger 0.24 (0.24) mm. long. Palp with maxilla 0.49 (0.49) mm. long, 0.35 (0.33) mm. wide; trochanter about 0.5 mm. long and 0.3 mm. wide; femur 0.8 (0.75) mm. long, 0.325 (0.325) mm. wide; tibia 0.83 (0.76) mm. long, 0.365 (0.33) mm. wide; chela exclusive of pedicle 1.38 (1.32) mm. long, wide exclusive of hook 0.525 (0.51) mm.; chelal hand exclusive of pedicle 0.67 (0.65) mm. long, 0.56 (0.54) mm. deep; movable chelal finger 0.75 (0.77) mm. long. First leg with pars basalis 0.212 (0.178) mm. deep; pars tibialis 0.17 (0.145) mm. deep; entire femur 0.63 (0.57) mm. long; tibia 0.465 (0.4) mm. long, 0.118 (0.106) mm. deep; tarsus 0.45 (0.41) mm. long, 0.076 (0.071) mm. deep. Fourth leg with pars basalis 0.194 (0.194) mm. deep, pars tibialis 0.24 (0.21) mm. deep; femur 0.78 (0.73) mm. long, tibia 0.64 (0.59) mm. long, 0.145 (0.13) mm. deep; tarsus 0.53 (0.48) mm. long, 0.092 (0.09) mm. deep; tactile seta present on tarsus as in the female.

Genital Complex.—Between 20 and 40 setae on the posterior operculum with 4 to 6 smaller setae on the very posterior rim of the genital aperture; nearly 30 scattered setae on the anterior operculum.

DISTRIBUTION.—This widespread eastern species, originally described from Florida, has been collected from nine localities in Illinois, ranging from the central to the southern part of the state.

Two collections were taken from fungi, one from a rotten log, three from tree holes, and three from ground cover and woody debris.

o from mammal nests, and one from the stomach of a red-bellied woodpecker.

Illinois Records.—CACHE: debris in hollow tree, April 19, 1944, Ross & Sanderson, 2 ♀. CAHOKIA: "50" on cork, Aug. 6, 1943, W. H. Snow, 1 ♀ (ws). HAVANA: debris and nest in log, Nov. 9, 1943, Ross & Sanderson, 1 ♀; ground cover below levee near river, Nov. 9, 1943, Ross & Sanderson, 1 ♀. MERRIN: July 24, 1944, W. Snow, 1 ♀ (ws). MOUNTAIN VIEW: leafy and woody debris on hillside, Sept. 30, 1943, Ross & Sanderson, 1 ♂. NARGA: fungus in tree hole, July 22, 1943, H. Ross, 2 ♀. QUINCY: near Burton's cave, mouse nest and dead wood in hollow log, April 27, 1944, C. Hoff, 1 ♂ (CH). SARBANA: in rotten log, March 29, 1942, H. Ross, 1 ♀; tree hole, Nov. 12, 1944, W. Snow, 1 ♀ (ws); University Woods, stomach of red-bellied woodpecker, Nov. 12-13, 1943, A. C. Toumey, 1 ♀ (HJV). WHITE OAK: "ex-fungi," Aug. 5, 1939, Ross & Sanderson, 2 ♀.

22. ILLINICHERNES new genus

DIAGNOSIS.—Chelicera with flagellum of four setae; basal seta of cheliceral hand acuminate, subbasal seta denticulate. Palps strongly stout; setae, figs. 46C-46E, of palps distad more especially of dorsum of body bilaterally feathered, leaflike, and stout; setae of sternal scuta chiefly clavate; proximal two-thirds of fixed chelal finger, fig.

46B, bearing long clavate setae; tactile seta distad of movable chelal finger closer to *t* than to *sb*; *ist* considerably distad from *est* on fixed chelal finger; both *ib* and *isb* distad from the level of *esb*; palps showing little sexual dimorphism. Tarsus of fourth leg without a tactile seta. Seminal receptacle of female not observed.

Genotype.—*Illinichernes distinctus* new species.

This genus appears closely related to the genus *Hesperochernes* Chamberlin, from which it may be separated without difficulty by the nature of the setae of the body and palps and the acuminate condition of the basal seta of the cheliceral hand. Only one species is known in the genus.

Illinichernes distinctus new species

This species is the only one known in the genus; hence, the diagnostic features of the genus are also the diagnostic features of the species. Several diagnostic structures are illustrated in fig. 46.

MALE.—Description based on three males, including the holotype. Measurements are given as the limits of range. Body stout; palps and legs moderately stout; body and legs light brown; palps deep reddish-brown or golden in color; body 1.7-1.85 mm. long. Carapace with anterior half rounded, lateral margins convex; surface coarsely granular; setae stout, wide, and feather-like in general appearance; no eye spots; median

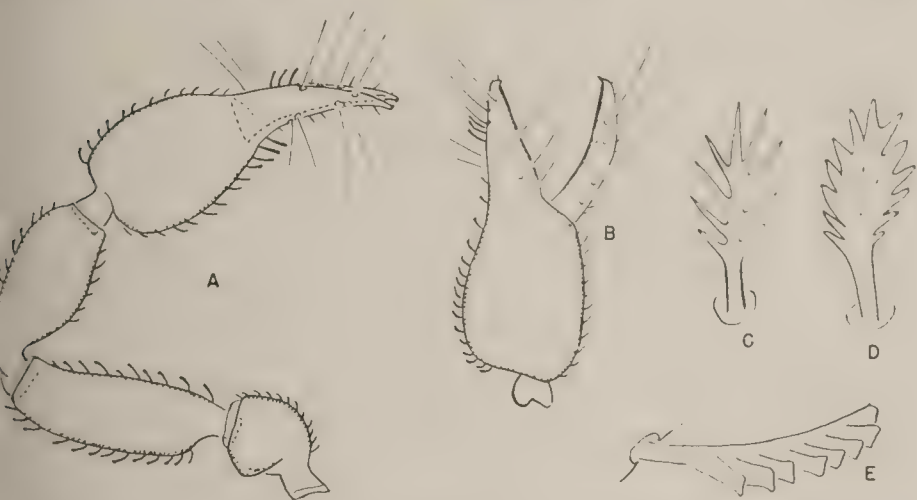


Fig. 46.—*Illinichernes distinctus*, holotype ♂. A, dorsal view of palp; B, lateral view of chela; C, a seta of the palpal femur; D, another seta of the palpal femur; E, side view of a seta from the palpal femur.

transverse furrow a little posterior to or near the center of the carapace, posterior furrow much nearer to the posterior carapace margin than to the median furrow; 12 to 14 setae along the posterior margin of the carapace; length of carapace 0.65–0.72 mm., greatest width near the center and equal to 0.62–0.65 mm.; posterior width very slightly less than the greatest width. Abdomen oval, very stout; tergites except the eleventh divided; surface of tergites granular; interscutal spaces not especially wide, usually narrow; each scutum of first tergite with six to eight setae; maximum number of setae on any tergite is about 11; all tergal setae stout and clavate, like those of the carapace. Sternites 4 to 10 divided, interscutal spaces narrow and striate; setae of sternal halves varying from subacuminate on the anterior part of the abdomen to strongly clavate on the central and posterior portions; each fourth sternal scutum with 5 or 6 setae, maximum number on central sternites about 10; surface of sternal scuta with scalelike markings. Each anterior stigmatic plate with two or three small acuminate setae, each posterior plate with three. Pleural membranes very rugose and irregularly striate; length of abdomen 1.05–1.13 mm., width about 0.95–1.02 mm.

Chelicera.—Yellow in color; fairly stout; exterior surface of base marked by weakly developed netlike lines; subbasal seta with three or four terminal and subterminal spinules; basal seta smaller and acuminate; largest flagellar seta unilaterally serrate along the distal half; the two smaller flagellar setae subequal in length; chelicera about 0.19 mm. long and with the base 0.12 mm. wide; length of movable finger between 0.145 and 0.165 mm. Fixed finger slender; three small rounded teeth on the inner surface of the apical tooth followed by four (of which the basal two are weak) denticles along the inner finger margin. Movable finger with a long and slender apical tooth, subapical lobe moderately well developed but much shorter than the apical tooth; galeal seta reaching about to the level of the tip of the galea; galea straight and with two or three very minute denticles (often not discernible) confined to the distal one-third of the galea; serrula exterior consisting of 15 or 16 ligulate plates.

Palp.—Fig. 46*A*. Coarsely granular except on the chelal fingers; most setae of maxilla weakly clavate, with numerous den-

tifications; setae of trochanter, femur, tibia and chelal hand clavate, stout, very similar to those of the carapace and tergites; fixed finger with long clavate setae on the dorsal and extensor surfaces of more than the basal one-half of the finger, setae of the remainder of the fixed finger and the entire movable finger acuminate. Maxilla 0.33–0.3 mm. long, 0.25–0.26 mm. wide. Trochanter with well-defined pedicle about as long as wide; subspherical in shape beyond the pedicle; sublateral and subdorsal protuberances rounded and not much elevated; thickly set with setae on the flexor surface but very few setae on the extensor surface. Trochanter 0.32–0.385 mm. long, about 0.21–0.242 mm. wide, length 1.5 to 1.6 times the width. Femur with a well-defined pedicle about as long as wide; femur subcylindrical beyond the pedicle except near the distal end; extensor margin flatly convex in the central part, a little more convex beyond; flexor margin very weakly convex in the central part and very weakly concave in the distal one-third or one-fourth; 0.6–0.69 mm. long, 0.21–0.225 mm. wide, length 2.85 to 3.05 times the width. Tibia pedicellate; extensor margin flatly convex in the central part but a little more convex near each end; flexor margin centrally rounded and somewhat bulging, flattened or very little concave in the distal part; tibia 0.57–0.63 mm. long, 0.225–0.25 mm. wide, length 2.5 to 2.5 times the width. Chela with both extensor and flexor margins of hand gently and evenly rounded; pedicle placed slightly toward the extensor margin; fingers relatively stout, slightly curved, and tapering gradually toward the distal end; chela exclusive of pedicle 0.84–0.955 mm. long, 0.34–0.36 mm. wide, length 2.45 to 2.6 times the width; chelal hand without pedicle 0.44–0.49 mm. long, 0.32–0.375 mm. deep; length of movable chelal finger 0.42–0.48 mm. From the side, chela, fig. 46*B*, fairly stout; pedicle displaced conspicuously toward the ventral side; ventral margin a little less convex than the dorsal margin; fixed finger stout and straight, tapering regularly toward the distal end; movable finger curved and more slender than the opposing finger. Movable finger with nodus ramosus between one and two areolar diameters basad from the level of tactile seta *st*. Tactile setae placed as shown in the figure. Marginal teeth of chelal fingers contiguous, and, except for a few proximal teeth, cusp-bearing

usually between 30 and 35 marginal teeth on each finger; movable finger usually with four or five external and one or two internal accessory teeth; fixed finger with seven or eight external and two or three internal accessory teeth. Vestigial venedens and short venom duct on fixed finger.

Legs.—Moderately slender; most segments except the tarsi sculptured by scale-like to granular markings; all setae except a few on the distal portion of the tarsi multidenticulate and clavate to subclavate. First leg with pars basalis 0.13–0.14 mm. deep; pars tibialis slender, extensor margin a little convex, flexor margin less convex to almost straight, 0.11–0.12 mm. deep; entire femur 0.42–0.47 mm. long, length 3.2 to 3.5 times the depth; tibia with flexor margin a little convex, extensor margin very weakly concave in the distal two-thirds, 0.32–0.35 mm. long, 0.08–0.086 mm. deep, length 3.95 to 4.1 times the depth; tarsus with the extensor margin almost straight, flexor margin a little convex, tapering somewhat toward the distal end, 0.34–0.38 mm. long, 0.058–0.064 mm. deep, length 5.85 to 6.4 times the depth. Fourth leg with the pars basalis 0.135–0.148 mm. deep; pars tibialis 0.145–0.159 mm. deep; entire femur fairly slender, extensor margin evenly convex, flexor margin nearly straight, 0.51–0.595 mm. long, length 3.45 to 3.8 times the depth; tibia weakly S-shaped, 0.43–0.48 mm. long, 0.09–0.1 mm. deep, length 4.6 to 4.9 times the depth; tarsus with both margins slightly convex, tapering in the distal one-half, 0.37–0.4 mm. long, 0.07–0.072 mm. deep, length 5.3 to 5.6 times the depth.

Genital Complex.—Anterior operculum with usually between 35 and 40 acuminate and well-developed setae; posterior operculum with four to six multidenticulate setae along the posterior margin, with a total of about 20 setae on the operculum.

FEMALE.—Measurements and ratios given are the ranges of three females, the allotype and two paratypes. Essentially like the male; body 1.95–2.05 mm. in length. Carapace with 14 to 16 marginal setae, 0.72–0.79 mm. long, greatest width 0.61–0.69 mm., posterior width little less than the greatest width. Abdomen 1.15–1.3 mm. long, 1.05–1.2 mm. wide.

Chelicera.—Chiefly as in the male except the galea with five terminal and subterminal ami, each minute and simple, but much more highly developed and conspicuous than

in the male; galeal seta not extending to the tip of the galea; serrula exterior of 16 to 17 plates; chelicera 0.21–0.22 mm. long, base 0.112–0.117 mm. wide, movable finger 0.15–0.155 mm. long.

Palp.—Virtually like that of the male. Maxilla 0.35–0.38 mm. long, 0.24–0.26 mm. wide, length 1.43 to 1.48 times the width; trochanter 0.36–0.39 mm. long, 0.22–0.24 mm. wide, length 1.58 to 1.6 times the width; femur measured along the extensor margin 0.64–0.73 mm. long, 0.21–0.225 mm. wide, length 2.97 to 3.22 times the width; tibia 0.58–0.66 mm. long, 0.225–0.25 mm. wide, length 2.43 to 2.64 times the width; chela exclusive of pedicle 0.88–0.975 mm. long, 0.325–0.37 mm. wide, length 2.55 to 2.7 times the width; hand of chela without pedicle 0.45–0.5 mm. long, 0.325–0.37 mm. deep; movable chelal finger 0.45–0.51 mm. in length. Tactile setae and teeth of chelal fingers as in the male.

Legs.—As in the male. First leg with pars basalis 0.133–0.143 mm. deep; pars tibialis 0.11–0.12 mm. deep; entire femur 0.44–0.51 mm. long, length 3.22 to 3.6 times the depth; tibia 0.34–0.38 mm. long, 0.085–0.09 mm. deep, length 3.92 to 4.22 times the depth; tarsus 0.35–0.38 mm. long, 0.065–0.07 mm. deep, length 5.0 to 5.6 times the depth. Fourth leg with pars basalis 0.137–0.152 mm. deep; pars tibialis 0.145–0.158 mm. deep; entire femur 0.56–0.64 mm. long, 3.65 to 4.05 times the depth; tibia 0.45–0.51 mm. long, 0.092–0.103 mm. deep, length 4.65 to 4.95 times the depth; tibia 0.39–0.42 mm. long, 0.069–0.076 mm. deep, length 5.3 to 5.8 times the depth.

Genital Complex.—Anterior operculum with 30 to 35 scattered setae; posterior operculum with 13 to 15 setae arranged in a single marginal row along the posterior margin of the operculum.

TRITONYMPH.—Observations and measurements based on three individuals. Body and appendages with color, sculpturing, and chaetotaxy much as in the adult; body 1.25–1.45 mm. long. Carapace usually with 10 to 12 setae along the posterior carapacic margin; carapace about 0.6 mm. long, 0.52 mm. wide. Tergites less sclerotic than in the adult; each first tergal scutum with five or six setae, central scuta with no more than eight setae. Sternites faintly sculptured, without color, weakly sclerotized; setae as in the adult, four or five setae on each fourth half-sternite, central sternal halves

with no more than six setae. Each stigmatic plate with two setae; abdomen 0.69–0.84 mm. long, 0.72–0.77 mm. wide.

Chelicera.—Like that of the female in all details including the nature of the galea, but smaller and less sclerotic. Chelicera 0.175–0.19 mm. long, base about 0.1 mm. wide; movable finger 0.13–0.135 mm. long; serrula exterior of 14 ligulate plates.

Palp.—Essentially like that of the male except the segments are smaller; the femur and tibia, especially the pedicles, are relatively stouter while the chela is a little more slender; the palps are a little lighter in color than in the male. Palps with maxilla 0.27–0.29 mm. long, 0.185–0.2 mm. wide, length about 1.45 times the width; trochanter about 0.285 mm. long, 0.17–0.18 mm. wide; femur measured along the extensor margin 0.45–0.47 mm. long, 0.16–0.17 mm. wide, length 2.75 to 2.85 times the width; tibia 0.42–0.45 mm. long, 0.175–0.185 mm. wide, length 2.4 to 2.45 times the width; chela exclusive of pedicle 0.66–0.68 mm. long, 0.245–0.25 mm. wide, length between 2.65 and 2.8 times the width; chelal hand without pedicle 0.33–0.34 mm. long, 0.24 mm. deep; movable finger 0.34–0.35 mm. long. From the side, the chelal hand appears less stout than that in the adult. Movable finger with three tactile setae: *t* about one-third of the finger length from the tip; *st* in the basal half of the finger and very little closer to *t* than to *sb*; *sb* between one-fourth and one-fifth of the finger length from the hand margin; *b* wanting; nodus ramosus about midway between *t* and *st*. Fixed finger with tactile setae much as in the adult except seta *ist* is wanting. About 25 or 30 marginal teeth on each finger; somewhat fewer accessory teeth than in the adult.

Legs.—Lighter in color, somewhat less sclerotic, smaller, and a little stouter than in the adult; surface of segments virtually without sculpturing; setae as in the adult. First leg with segments shaped much as in the adult except that the tibia and the tarsus are much stouter and the tarsus narrows more rapidly toward the distal end; entire femur 0.33–0.35 mm. long, length 3.1 to 3.2 times the depth; tibia 0.24 mm. long, 0.072–0.076 mm. deep, length 3.15 to 3.35 times the depth; tarsus 0.26–0.28 mm. long, 0.06–0.061 mm. deep, length 4.35 to 4.7 times the depth. Fourth leg much like that of the male; the flexor margin of the tibia evenly but weakly convex, the extensor mar-

gin virtually straight to a little concave in the distal two-thirds; the tarsus tapering markedly in the distal one-half; pars tibialis 0.114–0.122 mm. deep; entire femur 0.41–0.42 mm. long, length 3.45 to 3.6 times the depth; tibia 0.32–0.33 mm. long, 0.08–0.085 mm. deep, length 3.8 to 4.15 times the depth; tarsus 0.29–0.31 mm. long, 0.064–0.065 mm. deep, length 4.55 to 4.8 times the depth.

PROTONYMPH.—Description based on two individuals; measurements of one are given in parentheses after the measurements of the other whenever the two differ. Body stout; lighter in color than the adult; length 1.02 (0.94) mm. Setae of body, legs, and palps like those of the adult except much less numerous. Ten or 11 plates on the serrula exterior of the movable cheliceral finger. Palps much lighter in color than in the adult; surface of trochanter and femur granular, surfaces of tibia and chela slightly granulate or smooth; clavate setae on the side of the fixed chelal finger as in the adult. Palpal segments smaller and, with the exception of the chela, much stouter than in the tritonymph. Palpal femur 0.2 (0.21) mm. long, 0.095 mm. wide; tibia 0.2 mm. long, 0.105 (0.1) mm. wide; chela 0.39 (0.40) mm. long exclusive of pedicle, about 0.135 mm. wide; chela 0.135 mm. deep; hand exclusive of pedicle 0.2 (0.19) mm. long; movable finger 0.205 mm. long. Each chelal finger with between 15 and 20 marginal teeth, chiefly acuspid; no accessory teeth observed. Movable finger with one tactile seta (*t*?) near the center of the finger. Three setae on the fixed finger; two are external, one about one-third of the finger length from the tip and the other near the base; one is internal, located between one-third of the finger length from the base and the mid-point of the finger.

Holotype, male.—Magnolia, Illinois: decayed log, March 23, 1944, H. H. Ross.

Allotype, female.—Same data as for holotype.

Paratype.—ILLINOIS.—KELL: March 7, 1945, Ross & Sanderson, 2 ♂, 2 protonymphs, 1 tritonymph. MAGNOLIA: same data as for holotype, 2 ♀, 3 tritonymphs, 1 ♀ (CH).

No habitat data accompany the Kell collection.

23. *Genus? corticis* Ewing

Chelanops corticis Ewing (1911, p. 75).

In spite of the large number of collections available, I have been unable to associate

any of the Illinois specimens with *Chelanops corticis* described by Ewing. Since Ewing's description does not include generic key characters in use at present, and since it has been impossible to locate the types of this species, I am unable to assign *corticis* even tentatively to a genus. According to correspondence from J. C. Chamberlin, the species should serve as the genotype of a new genus. However, since no specimens are available for study, I hesitate to establish a new genus with *corticis* as the genotype.

From Ewing's description, it is apparent that the species belongs in the family Chernetidae and the subfamily Chernetinae.

On the basis of Ewing's description, it is possible to devise means of separating *corticis* from other species of the subfamily Chernetinae found in Illinois. Among the important characteristics listed for *corticis* in the original description and not found in other Illinois species are the following:

1. Galea very long, about two-thirds as long as the movable cheliceral finger.

2. The flexor margin of the palpal femur is bulging just distad from the pedicle; then is virtually straight for at least two-thirds of the length of the femur.

3. The flexor margin of the palpal tibia is markedly bulging in the basal half; then is virtually straight beyond; while the other margin beyond the pedicle is more or less evenly rounded.

4. The palpal hand is suboval in general shape and the palpal fingers are much stouter than in most species of Chernetinae.

5. The hairs of the fingers arise from minute tubercles.

Illinois Records.—In the original description two collections are cited, both from Illinois, as follows: **HAVANA:** from under bark of trees standing in water, Aug. 9, 1908, H. E. Ewing, 2 specimens; **URBANA:** March, 1902, J. W. Folsom, 2 specimens.

UNIDENTIFIED NYMPHS

Among the many collections examined, a few contained chernetid nymphs unassociated with adults or nymphs that are obviously of different species from the adults in the same collection. In these instances where certain association cannot be made between the immature and adult animals, it seems advisable to refrain both from describing the nymphs and from giving tentative identifications. Collections containing undeter-

mined nymphs are from Champaign, Mason, Iroquois, Vermilion, St. Clair, Alexander, Will, Jackson, Calhoun, Lake, Madison, and Kane counties.

ATEMINIDAE

Members of this family are rare in the Western Hemisphere, being typically Oriental and Ethiopian in distribution. One species, *Paratenuus elongatus* (Banks), is known from Florida.

CHELIFERIDAE

Pseudoscorpions belonging in this family may be recognized by the absence of accessory teeth from the chelal fingers and by the presence of a venom apparatus and tooth on each of the chelal fingers, fig. 51C. The world fauna of the family is divided into three subfamilies. One of these, fig. 47, the Cheliferinae, is present in the central and eastern part of the United States. Another subfamily, the Withiinae, is represented in the fauna of America north of Mexico only by a few species, restricted as far as known to Texas and California.

KEY TO SUBFAMILIES

Flagellum with four or five setae; usually some abdominal sternites of the males with clusters of microsetae; coxae of male without coxal sacs; well-developed genital sacs lacking. . . .

..... **Withiinae**
Flagellum with three setae; male without clusters of microsetae on abdominal sternites; coxal sac present in the fourth coxa; well-developed genital sacs usually present, fig. 10. **Cheliferinae**

Subfamily WITHIINAE

The subfamily is represented in the United States by only one genus, which has been reported from the southern part of the United States and from the West Coast region.

Subfamily CHELIFERINAE

The subfamily is characterized above in the key. Two tribes are described in the subfamily, both represented in Illinois.

KEY TO GENERA

1. Dorsal plates of the entire posterior half of the abdomen bearing a seta in the center of each of the sclerotized halves,

- fig. 51B, in addition to the peripheral setae..... 2
 Dorsal plates of the posterior portion of the abdomen having only peripheral setae on each of the sclerotized halves,

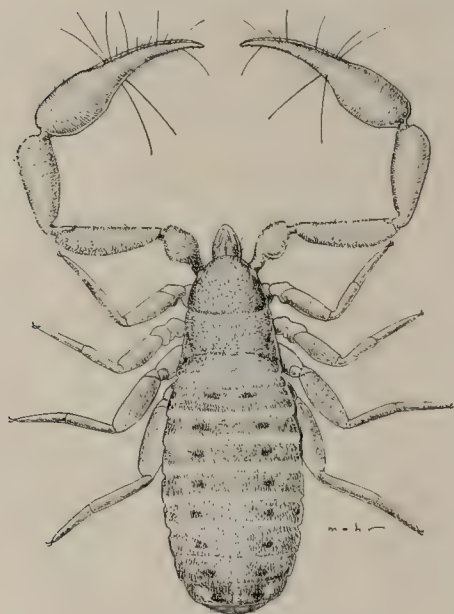


Fig. 47.—*Dactylochelifer copiosus*. An example of the suborder Monosphyronida and the family Cheliferidae.

- except occasionally on last one or two segments, fig. 50B..... 3
 2. Tarsal claws of at least legs II and III distally split or having a small to medium subterminal inner tooth, as in fig. 50D, but larger; plumose setae of the carapace arising from greatly enlarged tubercles or warts; statumen convolutum of the male genitalia invaginated anteriorly, containing a median sclerotized rod within the invagination; fourth coxal male genital sac without a differentiated median atrium..... 24. *Chelifer*
 Tarsal claws of all of the legs without lateral or inner teeth; plumose setae of the carapace not arising from conspicuously enlarged warts; statumen convolutum of the male genitalia rounded anteriorly, not cleft, and without a median sclerotized rod, fig. 10; fourth coxal male genital sac having a well-marked atrium medially, fig. 10..... 27. *Dactylochelifer*
 3. Tibia and tarsus of leg IV subequal in length; coxae without spurs..... 26. *Paisochelifer*

Tibia $1\frac{1}{4}$ times as long as the tarsus of leg IV; coxae IV of males with spurs near the anterolateral corner..... 25. *Idiochelifer*

Tribe CHELIFERINI

In this tribe the male has coxal sacs that lack well-differentiated atria and the statumen convolutum of the genital complex is invaginated anteriorly to form a median depression in which lies a sclerotic rod. The female, almost without exception, has the median cribriform plates paired and separate, not fused together.

About a dozen genera have been placed in this tribe of which eight are known from the nearctic and neotropical regions and three from Illinois. A key to all the genera in the tribe is given by Hoff (1946d).

24. *CHELIFER* Geoffroy

Chelifer Geoffroy (1762, p. 617). Genotype, by subsequent designation of Simon (1879): *Acarus cancroides* Linnaeus.

Chelifer Geoffroy. Chamberlin (1932, p. 19), Beier (1932c, p. 235).

DIAGNOSIS.—Cephalothorax and palps granular; cephalothorax with numerous large granules scattered among the others; eyes present; tergites divided, anterior tergites of the male with lateral keels. Flagellum with subbasal seta of the base absent. Palp slender. Tarsus of the first pair of legs in the male without terminal spine; subterminal setae of fourth pedal tarsus denticulate; tarsal claws bifid except for modified claws of first leg of male.

A single species occurs in North America.

Chelifer cancroides (Linnaeus)

Acarus cancroides Linnaeus (1758, p. 616).

Chelifer cancroides Fourcroy (1785, p. 526).

Chelifer muricatus Say, in part (1821, p. 63).

Chelifer cancroides dentatus Ewing (1911, p. 73).

Chelifer cancroides (Linnaeus). Beier (1932c, p. 236), Hoff (1944a, p. 123).

Inasmuch as *cancroides* is the only known Illinois species of the genus *Chelifer*, it can be identified on the basis of the generic characteristics, figs. 9, 48. Measurements of several Illinois individuals are given below to show the variation that occurs in the palpal segments.

Through the kindness of Henry Dietrich of the Cornell University Museum, I have examined six males of the type collection of

Chelifer cancroides dentatus Ewing from Otto, New York. All of these were found to be typical *cancroides*.

Several nymphs, apparently of this species, were found in some of the collections. These nymphs differ markedly from the adults by having entire and not toothed tarsal claws on the legs. A description of the nymphal stages is postponed until a larger number of specimens can be secured for study.

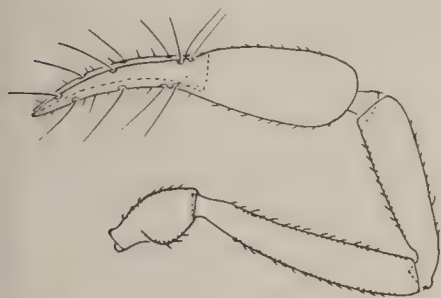


Fig. 48.—*Chelifer cancroides* ♀. Dorsal view of palp.

MALE.—Measurements and ratios are the ranges secured by measuring four males. Body length 2.55–3.2 mm.; palpal femur 1.16–1.29 mm. long, 0.21–0.25 mm. wide, length 5.2 to 5.55 times the width; tibia 0.95–1.15 mm. long, 0.24–0.275 mm. wide, length 3.85 to 4.1 times the width; chela exclusive of pedicle 1.6–1.85 mm. long, 0.4–0.475 mm. wide, length 3.9 to 4.1 times the depth; chelal hand exclusive of pedicle 0.75–0.9 mm. long, 0.36–0.45 mm. deep; movable chelal finger 0.85–1.05 mm. long.

FEMALE.—Measurements and ratios are given as the range of four females. Body length 3.3–3.7 mm.; palpal femur 1.15–1.2 mm. long, 0.21–0.25 mm. wide; length of femur 4.75–5.45 times the width; palpal tibia 0.95–1.05 mm. long, 0.24–0.28 mm. wide, length 3.75 to 4.1 times the width; chela exclusive of pedicle 1.55–1.8 mm. long, 0.37–0.46 mm. wide, length 3.95 to 4.25 times the width; hand exclusive of pedicle 0.75–0.85 mm. long, 0.35–0.45 mm. deep; movable finger 0.85–1.0 mm. long.

DISTRIBUTION.—This cosmopolitan species is invariably associated with man and may be found in dwellings, barns, granaries, beehives, and the nests of such birds as sparrows and starlings (Hoff 1944a). One collection in the present lot was taken from cattle. Although the species is thought to

molest man only infrequently, one collection was labeled "Attacking People."

The species is much more common than the number of collections reported here would indicate because most of the collections used in this study were taken from natural habitats. Most of the pseudoscorpions brought to schools and museums for identification are of this species; people ordinarily do not encounter the species that occur in soil, under the bark of trees, and in other natural habitats.

Ewing (1911) recorded *cancroides* and its varieties from several localities in Illinois. Several of these records apply to other species, but the record of one specimen from a house in Arcola is probably true *cancroides*.

Illinois Records.—Many specimens of both sexes have been collected from Arcola, Champaign, Chicago, Deerfield, Freeburg, Glencoe, Palos Park, Quincy, Roodhouse, Shumway, Springfield, Urbana, Waukegan.

25. *IDIOCHELIFER* Chamberlin

Idiochelifer Chamberlin (1932, p. 19). Genotype, by original designation: *Chelifer cancroides* var. *nigripalpus* Ewing. *Idiochelifer* Chamberlin. Hoff (1946d, p. 486).

DIAGNOSIS.—Cephalothorax a little longer than wide, with a few large, seta-bearing tubercles scattered among the investing granules; cephalothorax with two cross furrows; eyes present. Tergites divided, those of the male with crests or keels. Each coxa of the fourth leg of the male with a coxal sac and lateral spur; subterminal setae of the tarsus of the fourth leg *toothed*, not simple; tarsus of the first leg of the male without a terminal spine; claws of pedal tarsi simple except one claw of first leg of male with a well-developed accessory tooth; tarsus of the fourth leg with a tactile seta distad from the mid-point. Cribiform plates of female genitalia moderately small.

Among several females observed as belonging to the species *nigripalpus*, there was found one in which many of the tarsal claws of the legs have an accessory tooth. This is clearly an anomaly and does not necessitate a modification of the generic diagnosis.

The only species known in the genus occurs in Illinois.

Idiochelifer nigripalpus (Ewing)

Chelifer muricatus Say, in part? (1821, p. 63).

Chelifer cancroides var. *nigripalpus* Ewing (1911, p. 73).

Chelifer nigripalpus Ewing, Chamberlin (1931a, p. 52).

Idiochelifer nigripalpus (Ewing), Chamberlin (1932, p. 19); Hoff (1946c, p. 26).

Hysterochelifer longidactylus Hoff (1945b, p. 511).

It is probable that Say (1821) included specimens of *Idiochelifer nigripalpus* in his collection of *Chelifer muricatus*. Since types are not intact and since Say apparently based his description on several species, including *Chelifer cancroides* as indicated by the

here. Diagnostic parts are illustrated in figs. 49A–49C.

MALE.—Important measurements are given as the range of three males from Illinois. Body length 2.1–2.35 mm.; carapace 0.8 mm. long, ocular width 0.39–0.4 mm. Palpal femur 0.78–0.84 mm. long, 0.18–0.185 mm. wide, length 4.35 to 4.55 times the width; tibia 0.64–0.71 mm. long, 0.21 mm. wide; chela without pedicle 1.36–1.41 mm. long, 0.31–0.32 mm. wide, length 4.3 to 4.4 times the width; chelal hand exclusive of pedicle 0.63–0.65 mm. long, movable chelal finger 0.76–0.80 mm. long.

FEMALE.—Measurements of the palpal segments and body length are the ranges of four mounted females; other measurements are given as the ranges of three mounted individuals. Body length (abdomen somewhat contracted in some specimens) 2.1–2.55 mm.; carapace 0.82–0.86 mm. long, 0.8–0.86 mm. wide across the posterior margin; ocular width 0.4–0.44 mm. Chelicera about 0.24 mm. long, base 0.14–0.15 mm. wide; movable finger, fig. 49B, 0.18–0.195 mm. long. Palp, fig. 49A, with maxilla 0.4–0.45 mm. long, 0.26–0.29 mm. wide; trochanter about 0.43 mm. long, 0.24–0.25 mm. wide; femur 0.82–0.87 mm. long, 0.19–0.195 mm. wide, length 4.3 to 4.6 times the width; tibia 0.65–0.71 mm. long, 0.22–0.23 mm. wide, length 2.95 to 3.2 times the width; chela exclusive of pedicle 1.37–1.43 mm. long, 0.34–0.35 mm. wide, length 3.95 to 4.1 times the width; chelal hand exclusive of pedicle 0.65–0.68 mm. long, about 0.31 mm. deep; movable finger 0.75–0.79 mm. long. First leg with pars basalis 0.148–0.163 mm. deep, pars tibialis 0.137–0.14 mm. deep; entire femur about 0.5 mm. long; tibia 0.33–0.35 mm. long, 0.095–0.1 mm. deep; tarsus 0.35–0.37 mm. long, 0.072–0.076 mm. deep. Fourth leg with pars basalis 0.167–0.18 mm. deep, pars tibialis 0.243–0.265 mm. deep; entire femur about 0.7 mm. long; tibia 0.51–0.53 mm. long, 0.132–0.145 mm. deep; tarsus 0.4–0.415 mm. long, about 0.095 mm. deep; tactile seta located 0.28–0.30 mm. from the proximal margin of the tarsus.

DISTRIBUTION.—This species is known from several north-central states, including Illinois, Iowa, and Wisconsin. Undoubtedly several of Ewing's (1911) records of *cancroides* apply to this species. In the Museum of Comparative Zoology is a mounted female from Arcola (Douglas County), Illinois, that is labeled *Chelifer cancroides* and

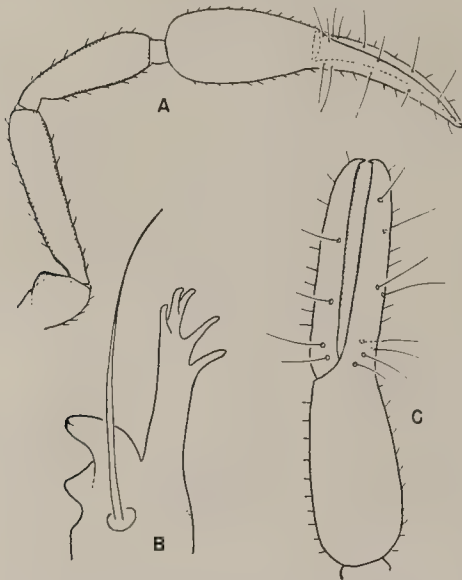


Fig. 49.—*Idiochelifer nigripalpus* ♀. A, dorsal view of palp; B, end of movable chelical finger; C, lateral view of chela.

record from a house, *Chelifer muricatus* must for all practical purposes be considered a *nomen nudum*.

In the original description of this species, no type specimens were indicated. Several specimens in the Cornell University collection are undoubtedly the types of the species, and one of these, from Ames, Iowa, was designated recently as the lectotype (Hoff 1946c).

Since the type specimens of this species have been described in some detail (Hoff 1946c) and the females have been described (Hoff 1945b) under the name *Hysterochelifer longidactylus* Hoff, only selected measurements of Illinois specimens are given

that apparently was reported under this designation by Ewing. A mounted male of this species from Clark County, Illinois, in the Ewing collection at Cornell is labeled *Chelifer cancroides* and apparently was not included among the records given by Ewing for Illinois. These and other records indicate a scattered distribution for the species over the central and northern parts of Illinois.

Seven of the Illinois collections of this species were made from the bark of living trees, chiefly oaks and hickories; the eighth collection lacks ecological data.

Illinois Records.—ALPHA: April 19, 1946, C. Hoff, 1 ♂, 1 ♀; April 20, 1946, C. Hoff, 2 specimens (CH). ARCOLA: July 21, 1909, H. E. Ewing, 1 ♀ (MCZ). FOX LAKE: June 11, 1947, Burks & Stannard, 2 specimens. HOMER: July 3, 1944, H. H. Ross, 1 ♀. MAHOMET: July 10, 1943, Ross & Beaver, 1 ♀, 1 tritonymph. MARSHALL: Oct. 31, 1908, J. L. Pricer, 1 ♂ (CU). ROCKFORD: Nov. 29, 1944, C. L. Remington, 1 ♀ (CR). STARVED ROCK STATE PARK: July 12, 1944, Frison & Sanderson, 1 ♀.

26. PAISOCHELIFER Hoff

Paisochelifer Hoff (1946d, p. 487). Genotype by original designation: *Hysterochelifer callus* Hoff.

DIAGNOSIS.—Carapace wider than long, uniformly granular; transverse furrows deeply impressed, the posterior furrow about one-half as far from the posterior carapacic

margin as from the median furrow; one pair of eyes. Tergites, including the eleventh, divided; lateral keels of the male wanting or very weakly developed. Flagellar setae of chelicera entire. Movable chelal finger with *st* nearer *sb* than to *t* and fixed finger with *est* and *ist* on nearly the same level and considerably proximad from the mid-point of the finger. Coxa of the fourth leg of the male with coxal sac; spurs of coxa IV lacking. Subterminal setae of the fourth tarsus weakly toothed. Tarsus of the first leg of the male without a terminal spine. Claws of pedal tarsi, except those of the first leg of the male, simple. A tactile seta located distad from the mid-point of the fourth pedal tarsus.

The genotype, the only species known in the genus, occurs in Illinois.

Paisochelifer callus (Hoff)

Hysterochelifer callus Hoff (1945b, p. 515).

Paisochelifer callus (Hoff). Hoff (1946d, p. 487).

The adults of this species have been described in detail in the original description (Hoff 1945b). Included here are additional data relative to the measurements of the body and palp, and illustrations of important structures, figs. 50A–50E. The deutonymph, previously unknown, is described in more detail.

MALE.—Measurements given as the range of three individuals, including the holotype. Body length 1.68–1.95 mm.; carapace 0.58–

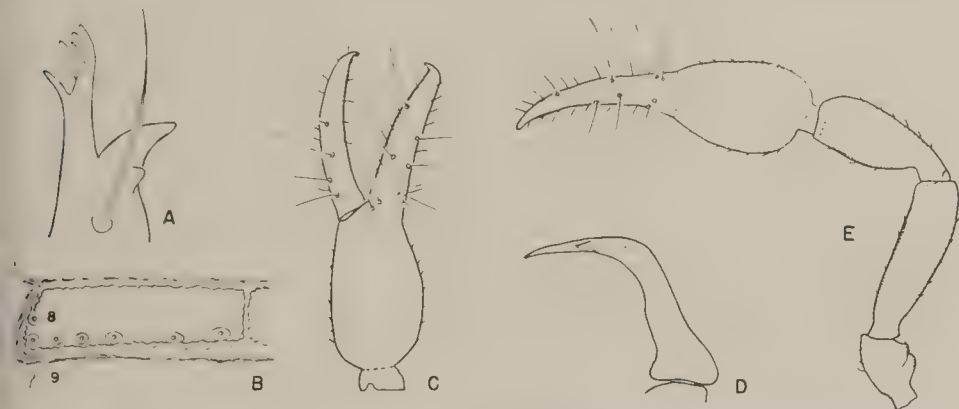


Fig. 50.—*Paisochelifer callus*. A, end of movable cheliceral finger, ♂ (many individuals, including the holotype, have two or three terminal and subterminal denticles on the apical tooth); B, setal map of left half of eighth abdominal tergite, holotype ♂; C, lateral view of chela, holotype ♂; D, lateral view of terminal claw of first leg, holotype ♂; E, dorsal view of palp, allotype ♀.

0.61 mm. long, greatest width 0.61–0.75 mm., ocular breadth 0.32–0.36 mm. Palp with trochanter 0.27–0.28 mm. long, 0.165–0.175 mm. wide, length 1.57 to 1.7 times the width; femur 0.52–0.56 mm. long, 0.155–0.165 mm. wide, length 3.35 to 3.5 times the width; tibia 0.47–0.5 mm. long, 0.18–0.197 mm. wide, length 2.5 to 2.65 times the width; chela exclusive of pedicle 0.89–0.945 mm. long, 0.27–0.295 mm. wide, length 3.2 to 3.45 times the width; chelal hand 0.41–0.46 mm. long exclusive of pedicle, 0.23–0.28 mm. deep; movable chelal finger 0.5–0.53 mm. long. Serrula exterior of the movable chelical finger with 17 or 18 plates.

FEMALE.—Measurements given as the range of five females, including the allotype and two paratypes. Body length 1.55–2.15 mm.; carapace 0.63–0.69 mm. long, width usually a little greater than the length but less than the length in one individual; ocular width 0.35–0.38 mm. Palp including trochanter 0.26–0.3 mm. long, 0.16–0.18 mm. wide, length 1.55 to 1.66 times the width; femur 0.59–0.61 mm. long, 0.165–0.175 mm. wide, length 3.45 to 3.65 times the width; tibia 0.48–0.54 mm. long, 0.19–0.205 mm. wide, length 2.4 to 2.7 times the width; chela of palp exclusive of pedicle 1.0–1.07 mm. long, 0.285–0.315 mm. wide, length 3.2 to 3.5 times width; chelal hand exclusive of pedicle 0.48–0.51 mm. long, 0.26–0.295 mm. deep; movable finger 0.53–0.59 mm. long.

DEUTONYMPH.—Body and legs light yellowish-brown, palps a little darker; body fairly stout, appendages usually stouter than in the adult. Body length 1.3 mm. Carapace shaped much as in the adult; furrows less well impressed than in the adult; six setae along the posterior carapacic margin; length of carapace 0.44 mm., posterior and greatest width 0.43 mm.; ocular width 0.25 mm. Tergites divided, marked by netlike sculpturing; nearly all tergal halves with three setae similar in nature to those of the adult. Most sternites weakly divided, with very weak, scalelike markings; usually three setae on each half-sternite. Stigmatic plates and pleural membranes as in adult; abdomen 0.85 mm. long, about 0.52 mm. wide.

Chelicera.—In general, similar to the chelicera of the adult except lighter in color and smaller; subbasal seta of palm of hand wanting; galea with four simple rami; serrula exterior with 14 plates; chelicera 0.155 mm. long; base 0.085 mm. wide; movable finger about 0.1 mm. long.

Palp.—Moderately granular except the chelal fingers, investing setae much as in the adult; segments, with the possible exception of the chela, conspicuously stouter than in the adult. Trochanter about 0.18 mm. long, 0.12 mm. wide. Femur subcylindrical, widened gradually toward the distal end, pedicle almost wanting; both flexor and extensor margins nearly straight; 0.312 mm. long, 0.11 mm. wide. Tibia with weakly developed pedicle much wider than long; flexor margin very weakly convex; extensor margin flatly convex; 0.285 mm. long, 0.133 mm. wide. Chela as viewed from the dorsum with both margins of hand moderately convex, the flexor more so than the extensor; hand gradually narrowed toward the finger base; fingers evenly and gently curved; chela exclusive of pedicle 0.61 mm. long, 0.185 mm. wide; chelal hand exclusive of pedicle 0.29 mm. long, 0.167 mm. deep; movable finger 0.33 mm. long. Viewed from the side, chelal hand appears subcylindrical, ventral margin nearly straight, dorsal margin a little convex; fixed finger nearly straight, movable finger slightly curved. Marginal teeth of the chelal fingers much like those of the adult except the teeth of the basal one-half of the row of the movable finger are acuspid; about 25 teeth on each finger. Movable finger with two tactile setae: one (probably *t*) located a little proximad from the mid-point of the finger; the second (probably *sb*) located twice as far from the first as from the proximal margin of the finger; nodus ramosus located a little distad from the mid-point of the finger. Fixed finger with six setae: *et* a little less than one-third of the finger length from the tip; *it* a little closer to *et* than the latter is to the finger tip; *est* removed from *et* by about the distance of *et* from the finger tip; both *it* and *est* proximad from the mid-point of the finger; one exterior and two interior basal and subbasal setae placed much as in the adult; probably missing setae are *ist* and *esb*; nodus ramosus located less than two areolar diameters basad from tactile seta *et*.

Legs.—General characteristics as in the adult but much lighter in color; less sclerotic, and segments smaller and stouter. All tarsal claws simple. First leg with pars basalis 0.08 mm. deep; entire femur 0.209 mm. long; tibia very stout throughout, 0.133 mm. long, 0.06 mm. deep; tarsus subfusiform, narrowing in the distal half, 0.173 mm. long, 0.05 mm. deep. Fourth leg with the pars tibialis

0.103 mm. deep; entire femur 0.285 mm. long; tibia 0.194 mm. long, 0.071 mm. deep; tarsus 0.209 mm. long, 0.057 mm. deep; the tarsus subfusiform, becoming much narrowed in the distal one-half and bearing a tactile seta that is located 0.145 mm. from the proximal margin of the segment.

DISTRIBUTION.—This species is known only from Illinois. It was described originally from Zion, and since then another collection has been taken in the same locality.

DIAGNOSIS.—Carapace longer than wide, moderately and regularly granular, with two cross furrows. Eyes present. Tergites divided, those of the male without lateral keels or with very weakly developed keels. Setae of body and palp short, toothed, or weakly clavate. Palps moderately slender, with uniformly granular surface; tactile seta *it* about in the middle between *et* and *ist* or somewhat nearer to *et*, fig. 51C. Anterior tarsus of the male always strongly modified, the

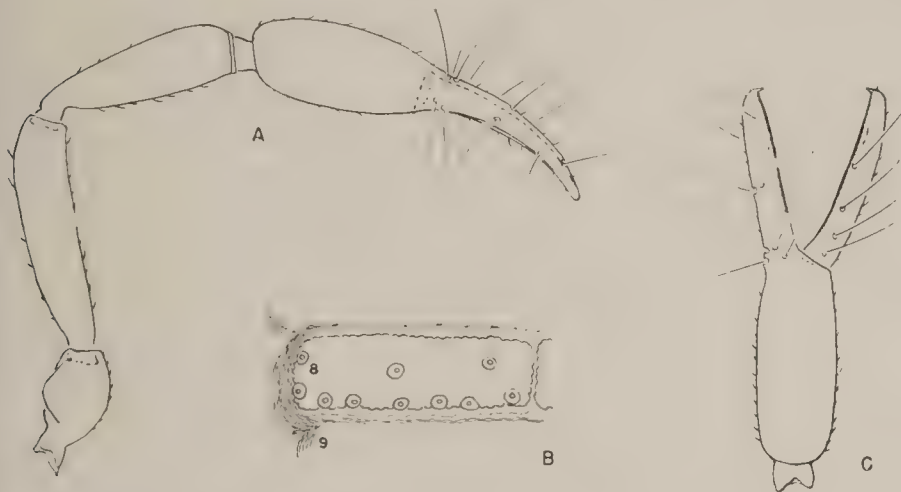


Fig. 51.—*Dactylochelifer copiosus* ♀. A, dorsal view of palp; B, setal map of left half of eighth abdominal tergite; C, lateral view of chela.

The type series was collected on March 17, 1933, from sand and grass roots in dunes area, Frison & Mohr, 1♂, 3♀; the later collection was made on October 15, 1942, from ground cover, Ross & Sanderson, 2♂, 2♀, 1 deutonymph.

Tribe DACTYLOCHELIFERINI

In this tribe, the males usually have a well-differentiated atrium in each coxal sac of leg IV and the sclerotic rod and anterior invagination of the statumen convolutum are always absent from the genital complex, fig. 10. The female has the medial pair of cribriform plates fused into one medial plate. Only one certain genus and one species are found in North America.

27. *DACTYLOCHELIFER* Beier

Dactylochelifer Beier (1932a, p. 64; 1932c, p. 253). Genotype, by original designation: *Chelifer latreillei* Leach.

claws asymmetrical; tarsal claws of other legs simple; subterminal setae of the tarsi simple; tarsus of leg IV without a tactile seta.

Only one species, *copiosus*, is known from the nearctic region, and this has been taken in Illinois. Other species of the genus occur throughout the palearctic region.

Dactylochelifer copiosus Hoff

Dactylochelifer copiosus Hoff (1945a, p. 53; 1945b, p. 521).

Adults of this species have been described in detail in the original description (Hoff 1945a). Additional data relative to the limits of range in size of the palpal segments and illustrations of important structures, figs. 10, 47, 51A–51C, are given here. In addition, brief descriptions are presented for the heretofore undescribed nymphal stages.

MALE.—Measurements given as the limits of range were secured by measuring 11 individuals from Illinois. Body length 2.3–2.6

mm. Palpal femur 0.8–0.91 mm. long, 0.193–0.215 mm. wide, length 3.9 to 4.25 times the width; tibia 0.72–0.82 mm. long, 0.225–0.245 mm. wide, length 3.0 to 3.4 times the width; chela 1.21–1.36 mm. long, 0.3–0.33 mm. wide, length 3.85 to 4.35 times the width; movable chelal finger 0.66–0.72 mm. long.

FEMALE.—Measurements given as the limits of range secured from seven individuals from Illinois. Body length 2.4–3.15 mm. Palpal femur 0.82–0.91 mm. long, 0.19–0.22 mm. wide, length 3.9 to 4.6 times the width but usually 3.9 to 4.2 times the width; tibia 0.74–0.85 mm. long, 0.225–0.245 mm. wide, length 3.2 to 3.55 times the width; chela exclusive of pedicle 1.26–1.43 mm. long, 0.33–0.355 mm. wide, length 3.75 to 4.25 times the width; chelal hand exclusive of pedicle 0.61–0.72 mm. long; movable finger between 0.7 and 0.75 mm. in length.

TRITONYMPH.—Measurements given as the limits of range of four individuals. In general, in appearance much like the adult except a little lighter in color and the segments of appendages much smaller and often a little stouter. Body 1.8–2.4 mm. long. Chelicera 0.195–0.22 mm. long, movable finger 0.14–0.15 mm. long; 16 or 17 plates in the serrula exterior. Palp with trochanter 0.32–0.35 mm. long, 0.185–0.19 mm. wide, length 1.65 to 1.85 times the width; femur 0.55–0.65 mm. long, 0.15–0.17 mm. wide, length 3.65 to 3.95 times the width; tibia 0.53–0.6 mm. long, 0.17–0.19 mm. wide, length 3.1 to 3.25 times the width; chela 0.9–1.1 mm. long, 0.23–0.26 mm. wide, length 3.9 to 4.3 times the width; chelal hand 0.46–0.56 mm. long, 0.21–0.25 mm. deep; movable finger 0.50–0.54 mm. long. Fixed chelal finger with seven tactile setae, arranged much as in the adult except *ist* wanting and *it* placed a little closer to the level of *est* than to the level of *et*. Movable finger with three setae, either *b* or *sb* wanting. About 40 or 45 marginal teeth on each chelal finger.

DEUTONYMPH.—Measurements given as the range of size of five individuals. Appendages and body much like those of the tritonymph except stouter and much smaller. Body length 1.45–1.6 mm. Serrula exterior of 13 or 14 ligulate plates. Palp with trochanter 0.23–0.24 mm. long, 0.125–0.135 mm. wide, length 1.75 to 1.85 times the width; femur 0.38–0.40 mm. long, 0.11–0.12 mm. wide, length 3.25 to 3.45 times the

width; tibia 0.35–0.37 mm. long, 0.13–0.1 mm. wide, length 2.55 to 2.7 times the width; chela 0.68–0.715 mm. long, 0.18–0.195 mm. wide, length 3.6 to 3.85 times the width; chelal hand 0.34–0.39 mm. long, 0.17–0.1 mm. deep; movable finger 0.34–0.37 mm. long. Movable chelal finger with two setae, one near the proximal margin, the other near the mid-point of the finger; homologous uncertain. Fixed finger with three exterior setae, either *eb* or *esb* wanting; three anterior setae as in the tritonymph except relatively closer to the level of *est*. Each chelal finger with about 35 marginal teeth.

PROTONYMPH.—Measurements based on five individuals. Appendages and body much smaller than in the deutonymph. Palpal segments smaller and, with exception of chela, appreciably stouter than in the deutonymph. Body 1.15–1.3 mm. long. Serrula exterior of chelicera with 12 plates. Palp with trochanter 0.17–0.18 mm. long, 0.11 mm. wide, length 1.6 to 1.8 times the width; femur 0.28–0.29 mm. long, 0.09–0.1 mm. wide, length 2.85 to 3.05 times the width; tibia 0.25–0.26 mm. long, 0.105–0.11 mm. wide, length 2.15–2.4 times the width; chela 0.55–0.58 mm. long, 0.145–0.16 mm. wide, length 3.55 to 3.8 times the width; chelal hand exclusive of pedicle 0.27–0.3 mm. long, 0.135–0.155 mm. deep; movable finger 0.29 mm. long. Movable chelal finger with one tactile seta located about one-third of the finger length from the proximal margin. Fixed chelal finger with two exterior setae, one located less than one-third of the finger length from the tip and the other placed near the base of the finger; a single seta of the interior series located near the finger base. About 30 teeth on each chelal finger.

DISTRIBUTION.—This species is known from only two states, Arkansas, from where it was originally described, and Illinois, from which it was recorded later (Harris 1945b). Illinois collections are from scattered localities over the state, with collections more abundant in the southern half.

Almost every collection was taken from ground cover and litter, although one was made while sweeping vegetation with a net.

ILLINOIS RECORDS.—All stages have been collected from Burksville, Edwardsville, Geff, Giant City State Park, Gillespie, Grand Detour (Castle Rock), Havana, Herod, Logan, Makanda, Murphysboro, New Columbia, Pere Marquette State Park, Vienna.

UNIDENTIFIED NYMPHS

Several collections contain nymphs of cheliferidae that I have found impossible inadvisable to determine as to genus or

species. These undetermined cheliferid nymphs are from the following counties: Adams, Carroll, Hardin, Jackson, Jersey, La Salle, Macoupin, Madison, Mason, Schuyler, and Union.

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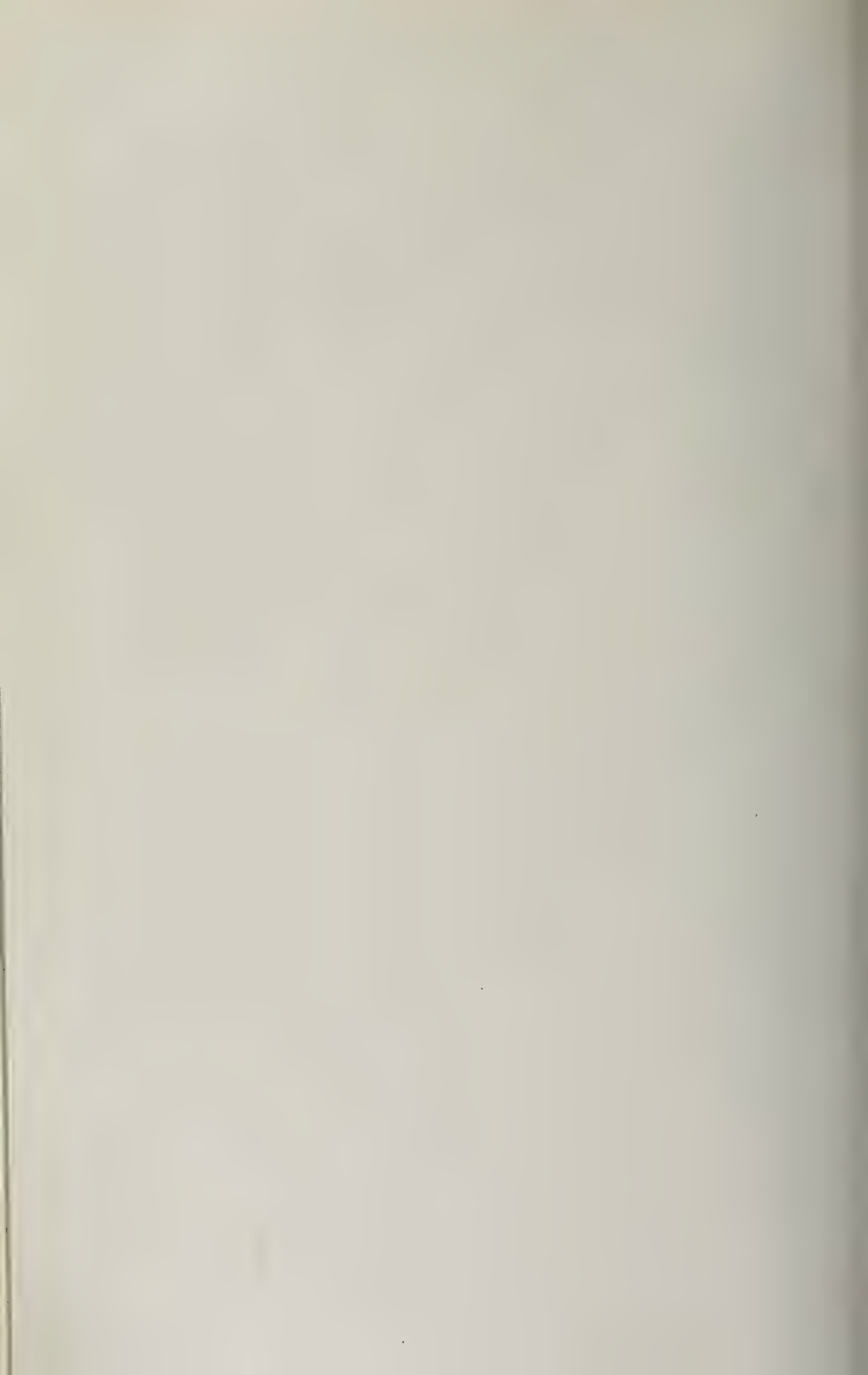
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This paper is a contribution from the Section of Publications and Public Relations.

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EMENDATIONS

Page 31, column 1, line 1. *For* tetrachoride *substitute* tetrachloride.

Page 124, column 2, line 5. *For jaimaicensis* *substitute* jamaicensis.

Page 238, column 1, line 7. *For* smaller *substitute* larger.

Page 261, column 2, line 28. *Add* of all individuals *following* rings.

BULLETIN

of the

ILLINOIS NATURAL HISTORY SURVEY

HARLOW B. MILLS, *Chief*

Characteristics of
Residual Insecticides
Toxic to the House Fly

WILLIS N. BRUCE



Printed by Authority of the
STATE OF ILLINOIS
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NATURAL HISTORY SURVEY DIVISION
HARLOW B. MILLS, *Chief*

Volume 25

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Article 1

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URBANA, ILLINOIS

July 1949

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Exposure of flies to surfaces treated with insecticides is quickly accomplished with the cages shown here. The cages are inverted and stacked, with a treated panel on each cage; then the sliding metal panel in each cage is withdrawn to allow flies in the cage to have direct contact with the treated panel.

Characteristics of RESIDUAL INSECTICIDES Toxic to the House Fly

WILLIS N. BRUCE

FOR centuries the house fly, *Musca domestica* Linnaeus, has been an annoying, disease-carrying menace to man and other animals. Spillman & Haushalter (1887) demonstrated the house fly to be a possible vector of *Bacillus tuberculosis*. Nuttal (1899) showed that *Spirillum cholerae* and staphylococci could be transmitted by house flies. Esten & Mason (1908) determined by counts that on an average a house fly carried 1,250,000 pathogenic organisms on its exterior surface. In a publication upon the typhoid or house fly, Felt (1909) estimated the indirect losses to our vital assets incurred by typhoid at 350 million dollars annually. Also, he suggested that house flies can spread plague, trachoma, and septicemic diseases. Howard (1909) wrote that the annual cost of screening against house flies in the United States is over 10 million dollars. Later, Herms (1911) stated that the public pays over 2 million dollars for fly traps, sticky fly paper, poisons, and sprays each year. Pipkin (1942) proved that *Musca domestica* can carry *Endamoeba histolytica* on its external surface and in its digestive system long enough to effect transmission. The evidence presented above, along with the list in Metcalf & Flint (1939) of 20 disease pathogens carried by flies, is more than sufficient reason to brand the house fly as potentially the animal most dangerous to human beings within the borders of the United States.

Although the house fly is important as an annoyance and as a vector of disease, it causes no direct injury to man or other animals. It is not equipped to bite or sting or in itself to cause disease by any of its life stages.

Pathogenic organisms may be carried on the surface of the fly's body, adhering to the numerous hairs, sticky pulvilli, wings, and mouthparts, or they may be carried in the alimentary canal to be spread by defecation or regurgitation. The filthy feeding and breeding habits of flies make inevitable the mechanical transmission of disease by these insects.

In Illinois, the house fly usually winters in the pupal or larval stage; a few adults live through the winter in protected places. The female fly deposits 2 to 21 batches of 100 to 150 eggs in manure or any other suitable decomposing organic matter. The whole life cycle through egg, larva, pupa to adult may be completed in 6 to 20 days. In Illinois there are usually 10 to 12 generations of house flies each summer. These facts account for the enormous build-up of flies that usually occurs during August or September in the temperate zone.

INSECTICIDES USED

The five chemicals described below are the principal insecticides used in the study reported here.

DDT (designation derived from the generic name dichloro-diphenyl-trichloroethane) was first synthesized by Zeidler (1874). Chemically this material is known as 2,2' bis (parachlorophenyl) 1,1,1-trichloroethane. The technical grade that was used in the experiments reported here consisted of a mixture of para, para'; para, ortho; and ortho, ortho' isomers. Pure DDT may be described as an odorless, stable, crystalline solid that is soluble in most organic solvents and insoluble in water. The first United States patent on it was granted to Paul Müller in 1943

for the Geigy Company Inc., of New York, N. Y. Although Wiesmann (1943) first described its usefulness as a residual insecticide for the control of house flies, Annand (1944) suggests that it was tested by Müller on house flies in 1940.

Rhothane D-3, or 2,2' bis (parachlorophenyl) 1,1-dichloroethane, a material closely related to DDT, was found by Müller and others to be of less promise as an insecticide than DDT. However, the Rohm & Haas Company was convinced it possessed some valuable insecticidal properties and consequently obtained a patent for its manufacture. *Rhothane D-3* (also known as TDE, DDD, and D3) is soluble in the same solvents as DDT; it has a higher vapor pressure and a lower melting point than DDT.

Chlordan or 1,2,4,5,6,7,8-octachloro-4,7-methano-3a,4,7,7a-tetrahydroindane was first synthesized by Dr. Julius Hyman and first discussed as an insecticide by Kearns, Ingle, & Metcalf (1945), who showed that when tested in a Peet-Grady chamber chlordan was three to four times as toxic to flies as DDT. In the highly refined state chlordan is a light yellow, viscous, nearly odorless liquid that is soluble in aliphatic, aromatic, and chlorinated hydrocarbons. It is infinitely soluble in kerosene, deobase, and no. 9 oil. Such solubility is not true of DDT, *Rhothane D-3*, or hexachlorocyclohexane, mentioned below. Chlordan has a specific gravity of 1.61 and weighs about 13.5 pounds per gallon.

The chemical 1,2,3,4,5,6-hexachlorocyclohexane was described by Slade (1945) as an insecticide with outstanding properties. According to Slade, Michael Faraday in 1825 first described the synthesis of hexachlorocyclohexane (referred to by Slade as Gammexane or 666) by the reaction of chlorine with benzene in the presence of sunlight. In 1943, Slade found the gamma isomer to be the toxic principle in the crude hexachlorocyclohexane. Usually the technical material has 10 to 12 per cent by weight of the gamma isomer. Pure gamma hexachlorocyclohexane has a faint musty odor, is a colorless crystalline material melting at 112.5 degrees C., and is soluble in most organic solvents.

Toxaphene, a technical chlorinated camphene with an approximate empirical

formula $C_{10}H_{10}Cl_8$, is a soft, waxy, light yellow material that melts at 65 to 90 degrees C. and has a density of 1.6. It is readily soluble in most organic solvents and insoluble in water. *Toxaphene*, formerly known as Hercules *Synthetic 3956*, is produced by the Hercules Powder Company of Wilmington, Delaware. Stearns (1947) indicates that *Toxaphene* has some promise as a household insecticide.

In addition to the insecticides described above are several on which preliminary studies were made.

PURPOSE OF STUDY

The purpose of this study was to obtain pertinent information about the residual insecticidal value of chlorinated hydrocarbons applied to various surfaces that had been exposed to different field conditions. The investigations conducted in 1943 at Orlando, Florida, by Lindquist *et al.* (1944) showed DDT to possess a high degree of residual toxicity to the house fly. They also showed a difference in toxicity of DDT when applied to painted and to unpainted wood. The need for the study reported here became apparent to the author when certain of his field applications of residual toxicants failed to effect adequate insect control. The results of this study, it is hoped, may serve as a guide to persons who are seeking to control insects through applications of residual insecticides and who are concerned with residues on plants.

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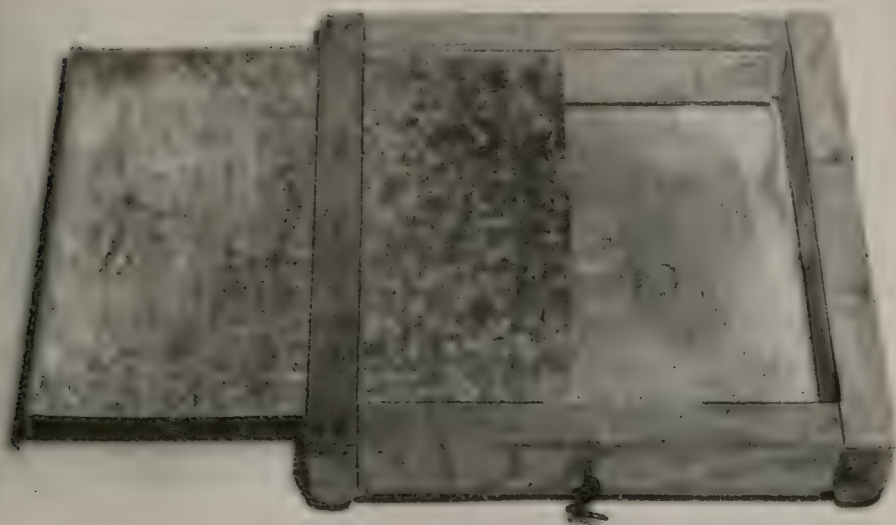


Fig. 1.—Exposure cage used in the experiments. As shown here, the cage is inverted, and the sliding panel is partly withdrawn.

Entomologist of the Illinois Natural History Survey, for constructive criticism of the manuscript.

TESTING PROCEDURE

A versatile flat exposure cage, fig. 1, was designed by the writer for use in the field, fig. 2, and for laboratory tests described below. The method of exposing cut film that photographers employ suggested its design. Made of a three-fourths inch white pine frame $8\frac{1}{2}$ inches square by $1\frac{3}{4}$ inches deep, the cage is covered on one side by 16-mesh screen wire and fitted on the other side with a sliding panel of manila paper or sheet metal. It has an interior space of about 75 cubic inches. More than 300 cages of this design were required for the tests.

All house flies used in the tests were reared according to the accepted Peet-Grady method (Anonymous 1946). About 120 pupae (2.2–2.4 grams) were placed in each exposure cage via the sliding panel, fig. 1. Flies were supplied with food, a mixture of milk and water, by means of a small shell vial fitted with a piece of cheesecloth. A shell vial was inverted up-

on the screen top of each cage, permitting the adult flies to feed by contact, fig. 3. In each test of an insecticide, adult flies were exposed to a treated surface on their second day of oviposition, and on the following day the mortality counts were made.

The exposure process was simple. First the cage was placed on a clean, flat board and then the sliding panel was removed momentarily to allow the empty pupal cases and other debris to fall out. With the panel replaced, the cage was moved and secured to the treated surface. The sliding panel was then removed to allow the flies to have direct contact with the treated surface for the desired exposure period. Obviously because of the house flies' habit of seeking the ceiling as a resting place when illumination is reduced, preliminary tests under average laboratory lighting indicated that best replication was obtained by inverting the cages (screen side down) during the exposure, frontis-piece. However, in bright light and at temperatures between 80 and 90 degrees F. there was little difference between results from the upright and the inverted position during exposure.

The treatment of the selected surfaces was simple and yet apparently reliable. In the early tests, the quantity of prepared insecticide, containing 1 per cent of the

ing spray tower, fig. 5. A Tattersfield spray apparatus was fitted with smaller openings in order to reduce the particle size to 2-50 microns range. Even distr



Fig. 2.—Practical method (not used in the experiments) of testing the toxicity of wall surfaces treated with residual insecticides. The exposure cage is hooked to the treated wall, and the metal panel is withdrawn to give flies in the cage direct contact with the wall for a given period of time.

residual toxicant by weight, was measured with a pipette and spread evenly over the surface with the aid of a small brush, fig. 4. Additional water or solvent was used to wash the residue from the brush onto the surface.

In later tests the deposits were obtained by means of a 6-foot stainless steel settl-

ing spray tower, fig. 5. A Tattersfield spray apparatus was fitted with smaller openings in order to reduce the particle size to 2-50 microns range. Even distr

tribution and good replication (less than 1 per cent variation among deposits) were obtained with this apparatus, fig. 4. The following are some of the common formulations of the concentrates used in making 1 per cent sprays. Formulations other than these are indicated in the discussion of individual tests.

A. Emulsions:

1. 62% chlordan + 5% *Atlox* 1045-*A* + 33% no. 9 oil by volume.
2. 25% DDT, *Toxaphene*, gamma isomer of hexachlorocyclohexane or *Rhothane D-3* + 70% *PD 544-C* (solvent known also as *Sovacide 544-C*) + 2% emulsifier *B-1956* and 3% *Triton X-155* by weight.

B. Water-wettable powders: 50% by

weight of toxicant + 2% wetting agent (*Triton X-100*) + 48% by weight of *Cherokee* clay.

C. Oil solutions: 1.0% by weight of toxicant per volume of no. 9 oil.

After each test the cages were decontaminated in a mild KOH solution, washed thoroughly in soapy water, and allowed to dry in the sun for about 2 days. The manila sliding panels were discarded after being used once. With this procedure no contamination difficulties were met.



Fig. 3.—Method of feeding flies in exposure cage. A shell vial filled with milk and stoppered with one layer of cheesecloth is inverted and placed on the screen top of the exposure cage.

Experiment 1: Exposure Time for Knockdown and Mortality.—In an experiment designed to reveal the exposure times necessary to give comparable mortalities for the five principal materials tested, as well as to indicate the relative initial surface toxicity and speed of knockdown of flies, lots of 100 to 120 flies each

haps Monro and his co-workers used surfaces on which only a small amount of DDT was available to the flies, and in the first few minutes of exposure the flies rapidly eroded or removed the DDT available. In speed of knockdown, gamma hexachlorocyclohexane was the material ranking first; it was followed in order by

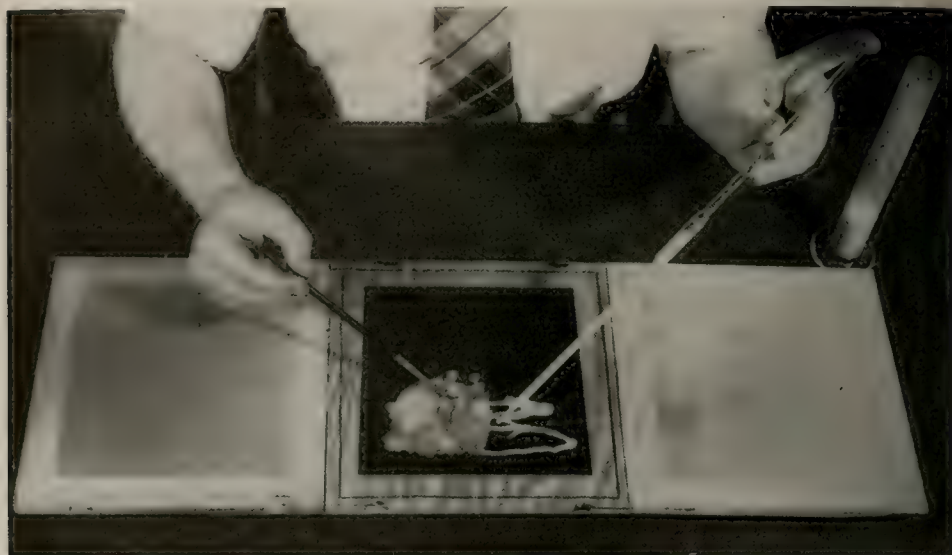


Fig. 4.—Three glass panels similar to those used in experiment. Left, panel with insecticide applied in settling spray tower; center, panel with insecticide being applied by means of brush and pipette; right, panel with insecticide already applied by means of brush and pipette.

were exposed to deposits of 50 mg. per square foot (538 mg. per square meter) of glass for each of three replicates.

Table 1 clearly reveals the correlation between the length of exposure and the percentage of mortality and knockdown resulting from each of the five principal chlorinated hydrocarbons used. The surface toxicity as indicated by the exposure needed to effect mortality made DDT and gamma hexachlorocyclohexane appear to be the most toxic, with chlordan, *Rhothane D-3*, and *Toxaphene* following in order.

Monro, Beaulieu, & Delisle (1947) reported no difference in mortality among lots of flies exposed for 10, 20, 30, 40, and 50 minutes to DDT deposits. Their reported results are at variance with data obtained from the experiment described here. Table 1 exhibits clearly the relationship of exposure time to mortality. Per-

DDT, *Rhothane D-3*, chlordan, and *Toxaphene*. Fifty per cent knockdown of house flies when exposed to *Toxaphene* was reported by Block (1948b) to require in some instances only 12 minutes, a period that represents a much faster knockdown rate than the 4 to 6 hours for complete knockdown reported by Beacher & Parker (1948). Data in table 1 indicate that about 167 minutes of exposure to *Toxaphene* is needed to give 50 per cent knockdown and 253 minutes for 99 per cent knockdown. It was noticed in the experiment reported here that there was no correlation between time required for knockdown and time required for kill. *Rhothane D-3*, which possessed much less surface toxicity than chlordan, actually gave quicker knockdown. Surface toxicity depends upon the availability of the insecticide as well as the actual toxicity.



Fig. 5.—Settling spray tower. Insecticide is introduced by a pipette into the atomizer at top settling spray tower. A panel is placed on a sliding shelf in the bottom of tower. At 12.5 lbs air pressure, and after 3 minutes are allowed for settling, the dosage per square foot of panel is approximately 32.4 per cent of the quantity placed in the atomizer.

Table 1.—Effect of exposure time on mortality of house flies and time required various knockdowns of flies by five chlorinated hydrocarbons when applied as suspensions on glass.

WATER-WETTABLE INSECTICIDE	MG. TOXICANT PER SQUARE FOOT	PER CENT MORTALITY 24 HOURS AFTER EXPOSURE TIME OF								MINUTES REQUIRED FOR KNOCKDOWN OF			
		5"*	15"	56"	3' 45"	7.5' †	15'	60'	240'	10%	50%	90%	99%
50% DDT	50 mg.	5.2 12.4 8.0	57.2 64.5 42.8	81.2 75.4 84.7	96.3 90.1 87.6	99.3 100.0 97.2	97.8 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	20 29 22	32 35 34	45 46 45	
Mean.....		8.5	54.8	80.4	91.3	98.8	99.3	100.0	100.0	24	34	45	
50% Chlordan	50 mg.	—	2.8 5.0 3.2	11.1 16.4 12.1	47.5 53.9 40.7	74.7 82.6 66.0	96.5 98.9 94.7	100.0 99.2 100.0	100.0 100.0 100.0	61 64 68	80 84 85	100 110 113	
Mean.....		—	3.7	13.2	47.4	74.4	96.7	99.7	100.0	64	83	108	
5.2% Gamma hexachloro-cyclohexane	50 mg.	—	12.6 7.0 19.8	36.9 45.1 35.8	79.7 52.7 67.3	67.6 91.4 83.7	84.4 100.0 100.0	100.0 100.0 100.0	100.0 100.0 100.0	13 17 15	17 20 29	33 38 45	
Mean.....		—	13.1	39.3	66.6	80.9	94.8	100.0	100.0	15	22	39	
25% Toxaphene	50 mg.	—	—	9.7 3.8 10.2	16.6 12.1 18.3	—	31.8 28.4 34.1	69.7 72.5 65.3	98.2 95.0 99.1	100 120 117	165 160 175	195 197 205	
Mean.....		—	—	7.9	15.7	—	31.4	69.2	97.4	112	167	199	
50% Rhothane D-3	50 mg.	—	—	1.7 0.0 0.9	2.0 6.5 3.9	—	20.0 24.7 17.8	79.5 84.1 87.1	100.0 99.1 100.0	40 40 47	57 55 58	80 90 84	
Mean.....		—	—	0.9	4.1	—	20.8	83.6	99.7	42	57	85	

* " = seconds.

† ' = minutes.

In table 1 are indicated the proper exposure periods to be used in the experiments on residual toxicities, as follows: DDT and gamma isomer of hexachlorocyclohexane, 15 minutes; chlordan, 1 hour; and Rhothane D-3 and Toxaphene, 2 hours. Exposures to deposits of 50 mg. toxicant per square foot for the periods indicated produced nearly 100 per cent mortality for each material.

Experiment 2: Effect of Deposits on Mortality.—With what appears to be the best residual material (DDT) a study was conducted to establish if possible the influence of the amount of deposit on mortality of flies exposed 15 minutes. A series of glass plates were treated with a 50 per cent DDT water-wettable powder in a calculated range of 0.1875 mg. to 200 mg. (equivalent to 2,152 mg. per square

Table 2.—Mortalities of house flies exposed 15 minutes to various DDT suspension deposits on glass.

DEPOSIT AS MG. OF DDT PER SQUARE FOOT OF GLASS	PER CENT MORTALITY 24 HOURS AFTER TREATMENT			M
	Replicate 1	Replicate 2	Replicate 3	
200 0	100.0	99.0	100 0	9
50 0	100.0	98.1	100 0	9
25 0	81.6	100.0	100 0	9
12.5	89.8	100.0	94.3	9
6 25	75.0	85.5	100 0	8
3 125	55.3	46 1	88.7	6
1.50	25.0	28.1	37.8	3
0.75	19.0	18.8	12.4	1
0.375	0.0	5.7	0.0	
0.1875	0.0	3.1	0.0	
0 0	0.0	2.1	0.0	

NOTE: A 50 per cent DDT water-wettable powder was used to secure the DDT deposits.

Table 3.—Mortality of house flies exposed to surfaces sprayed with DDT at different dosages and degrees of coverage.

MG. OF DDT PER SQUARE FOOT	PER CENT OF SURFACE SPRAYED	PER CENT MORTALITY 24 HOURS AFTER EXPOSURE OF				
		3 Seconds	15 Seconds	1 Minute	4 Minutes	16 Minutes
50	100	24.7	88.5	99.1	99.8	100.0
100	25	5.5	15.0	75.8	100.0	99.7
25	100	19.2	86.0	96.5	99.0	100.0
10	100	10.4	25.0	82.5	94.8	99.1

eter) DDT per square foot. Table 2 shows that a rather sharp drop in mortality did not occur until the deposit was 6.25 mg. per square foot or below. In this experiment, 25 mg. of DDT per square foot was nearly as effective as a 200 mg. deposit; calculations were based on the 24-hour mortality resulting from a 15-minute exposure. There was evidence of mortality occurring from a deposit as low as 0.375 mg. DDT per square foot. A dosage of 50 mg. of toxicant per square foot was selected as high enough for obtaining critical information on persistence of deposits in succeeding tests. The writer felt that for critical residual studies excessive deposits might obscure differences in persistence.

Experiment 3: Relationship Between Coverage and Deposit.—

Deenate water-wettable powder mixtures at various dosages were sprayed in a settling tray tower upon glass plates in such a way as to obtain various degrees of coverage, as indicated in table 3. A 25 mg. per square foot deposit over 100 per cent of the surface was much more effective than a 100 mg. per square foot deposit over only 25 per cent of the surface. A deposit of 100 mg. of DDT on 25 per cent of the surface was no more effective than a 10 mg. deposit over the entire surface (about 0.4 as much actual DDT). Results show the greater importance of coverage and the lesser importance of dosage in effecting fly mortality.

No critical comparisons can be made between data obtained in this experiment and data on coverage obtained by Turner & Woodruff (1948), as in the Turner & Woodruff report comparable specific information is lacking on techniques of dosage, dosages, exposure times, numbers of flies used, and effect of flies on deposits.

Table 4.—Mortality of house flies exposed to surfaces sprayed for different degrees of coverage with 50 mg. DDT deposits per square foot.

PER CENT OF SURFACE SPRAYED	PER CENT MORTALITY 24 HOURS AFTER 4- MINUTE EXPOSURE
10	12.5
20	64.0
30	91.1
40	99.0
50	99.6
100	100.0

Experiment 4: Coverage of Surface and Fly Mortality.—As indicated in table 4, six panels were sprayed, with 10, 20, 30, 40, 50, and 100 per cent, respectively, of their surfaces covered with 50 mg. of DDT per square foot in the form of a water mixture of *Deenate* water-wettable powder.

On panels on which less than 30 per cent of the surface was treated, fly mortality resulting from a 4-minute exposure was low. Probably the fly does not have sufficient time to pick up a lethal dose of DDT in a 4-minute period of contact with a surface less than 30 per cent of which is treated.

Table 4 shows, in the random distribution of flies within a confined space, the desirability of extensive treatment, or as nearly complete a coverage as possible.

Table 3 indicates that a given amount of material is most effective when distributed over the whole surface. Therefore, in practical application, if a certain amount of material is to be used upon premises, it is advisable to cover all surfaces rather than to employ spot treatments, provided, however, that such an entire-coverage treatment does not con-

Table 5.—Mortality of house flies exposed to surfaces sprayed with DDT distributed heterogeneously and also homogeneously.

FORMULATION	MG. DDT PER SQUARE FOOT	AVERAGE MG. DDT PER SQUARE FOOT	SURFACE	PER CENT MORTALITY 24 HOURS AFTER EXPOSURE OF	
				15 Seconds	4 Minutes
No. 9 oil solution.....	20-200	110	Wood	96.0	100.00
No. 9 oil solution.....	110	110	Wood	93.2	100.00
No. 9 oil solution.....	50	50	Wood	87.0	99.08
<i>Deenate</i> water-wettable DDT powder in water....	25-75	50	Glass	89.6	99.10
<i>Deenate</i> water-wettable DDT powder in water....	50	50	Glass	88.1	99.40

taminate food or otherwise present a health hazard.

Experiment 5: Effect of Heterogeneous Deposits Upon Flies.—The effect upon flies of uneven deposits of insecticides was determined through a series of tests in which materials were sprayed on surfaces in alternating bands of heavy and light deposits. DDT, 3.2 per cent, in no. 9 oil was sprayed in 10 alternating bands of 20 and 200 mg. per square foot upon a wood surface, and the resulting mortality in flies exposed to this surface was compared with resulting mortalities in

flies exposed to one 110 mg. and one 50 mg. treatment. There was, of course, a certain amount of run-together of the bands (estimated at about 25 per cent) so that the crystalline deposit appeared wavelike, or as a truly uneven deposit. There was no significant difference in fly mortality resulting from exposure to the 20-200 mg. deposit and the deposits of 110 and 50 mg. No significant differences in fly mortality resulted when *Deenate* water-wettable DDT was applied to glass in four strips of 25 and 75 mg. per square foot and in a uniform deposit of 50 mg., table 5.

The tests described above lead to the

Table 6.—House fly knockdown and mortality resulting from 15-minute exposures to surfaces treated with several formulations at a dosage of 50 mg. DDT per square foot.

PER CENT DDT IN WATER-WETTABLE POWDER	SOURCE OF TOXICANT	SURFACE	MINUTES REQUIRED TO OBTAIN KNOCKDOWN OF			MORTALITY 25 HOURS AFTER A 15-MINUTE EXPOSURE
			1%	50%	99%	
50.0	Rohm & Haas 50% water-wettable powder	Glass	20	33	57	100.0
25.0	Rohm & Haas 50% water-wettable powder	Glass	22	36	58	99.2
10.0	Rohm & Haas 50% water-wettable powder	Glass	29	49	145	89.1
5.0	Rohm & Haas 50% water-wettable powder	Glass	38	72	290	49.9
2.0	Rohm & Haas 50% water-wettable powder	Glass	50	140	540	14.0
0.5	Rohm & Haas 50% water-wettable powder	Glass	360	1,080	2,830	1.3
5.0	<i>Deenate</i> 50% water-wettable powder	Glass	35	58	315	46.2
5.0	<i>Deenate</i> 50% water-wettable powder	Wood	40	60	340	37.4
5.0	<i>Deenate</i> 25% emulsifiable concentrate	Glass	55	215	1,290	10.1
5.0	<i>Deenate</i> 25% emulsifiable concentrate	Wood	25	35	58	95.3

conclusion that perfectly uniform deposits may not be necessary or even advantageous on surfaces on which residual toxicant deposits are excessive. This conclusion confirms results of experiments in which there was no apparent difference in mortality rates resulting from deposits obtained by spraying and those obtained by painting. The painted deposits were obviously not perfectly uniform, fig. 4.

Experiment 6: Wall Coats Containing DDT.—When many so-called wall coats containing DDT appeared upon the market, laboratory tests were progressing upon amounts of DDT in the suspension-type wall coats needed to produce the necessary lethal action. In addition, a means was being sought whereby a good wall coat might be produced. Formulations containing 0.5, 2.0, 5.0, 10.0, and 25.0 per cent DDT were prepared from Rohm & Haas wettable DDT powder and sprayed upon glass panels at the rate of 50 mg. actual DDT per square foot. The treated panels were permitted to dry and age 4 weeks before being tested.

The data in table 6 make it evident that mortality and knockdown were not changed until the concentration of DDT was reduced to 10 per cent or less. The writer is doubtful if any wall coat containing as little as 2 to 5 per cent DDT could compete in fly control with 50 per cent DDT water-wettable powder in field operations. In the 50 per cent water-wettable powder, approximately half of the surface particles are actual DDT, whereas in the wall coat probably 2 to 5 of 100 surface particles are actual DDT.

A few experiments with laboratory wall-coat formulations, in which 25 per cent DDT emulsifiable concentrate was reduced to 5 per cent DDT by mixture with *Cherokee* clay and used in place of the water-wettable powder, proved quite satisfactory. When this formulation was sprayed upon wood or other porous surfaces a highly toxic bloom occurred usually within a week. When applied to glass, the DDT "bloomed-in" and crystallized upon the glass beneath. Used commercially, such a formulation would probably not be sprayed upon glass or other highly polished surfaces and would likely surpass most wall coats being used in controlling flies.

Block (1948a) mentions a number of good references to research on insecticidal surface coatings. Also, he offers valuable information about such coatings, in which the toxicant appears to be retained longer than might ordinarily be expected. Most of Block's work was with coatings containing 20 per cent DDT, and his data are recorded in number of minutes required to give 50 per cent knockdown.

Experiment 7: Effect of Successive Exposures on Persistence of Toxic Residue.—What wearing effect do numerous flies have upon a deposit of residual insecticide? Ten cages of flies were exposed for successive periods of 15 minutes each to each of the DDT-treated surfaces listed in table 7, and 24-hour mortality data were recorded.

Results of tests, designed to test fly erosion of DDT residues, indicate not only tenacity of deposits but also a stimulating seeding effect of flies when exposed to surfaces that are just beginning to bloom. On such surfaces it is evident that there exists a layer of blobs of supersaturated solvents that respond to various stimuli and bloom out in a dense mat of very fine crystals. These stimulated blooms (crystallization on the surface) are, according to the erosion test, very resistant to wear.

Examining the data by solvents and surfaces reveals some very interesting trends. *PD 544-C* emulsions, when applied to wood, form not only a good initial bloom but also a very dense secondary seeded mat of crystals, all of which resist wear. On glass the *PD 544-C* formulation maintains a rather low order of toxicity, with no apparent loss by fly erosion. Microscopic examination of deposits of DDT from the slower-drying solvents shows that the large crystals for the most part lie flat upon the glass surface, figs. 6, 9, and 10. The position of the crystals probably explains their low degree of toxicity and their long wear. A mixture of water-wettable powder that has been sprayed on glass erodes to some degree as evidenced by both biological and visual observations. Erosion of the residue is greatly retarded by the addition of 5 per cent bone glue by weight to the 50 per cent DDT water-wettable powder. The *Deenate* water-wettable powder appears to erode more

Table 7.—Influence of surfaces, solvents, formulations, method of application, and fly activity upon toxicity and maintenance of residual effectiveness of DDT deposits.

PANEL No.	SOLVENT OR FORMULATION	METHOD OF APPLICATION	AGE OF DEPOSIT IN DAYS	CRYSTALS	SURFACE	PER CENT MORTALITY 24 HOURS AFTER STATED EXPOSURE OF FLIES TO THE SURFACE									
						1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1	PD 544-C*	Painted..	6	Medium fine....	Wood	100.0	100.0	100.0	100.0	92.0	90.0	87.0	99.0	98.0	83.0
2	PD 544-C*	Painted..	6	Medium fine....	Wood	100.0	97.0	100.0	100.0	88.0	100.0	90.0	87.0	96.0	100.0
3	PD 544-C*	Painted..	6	Large.....	Glass	16.0	37.0	17.0	28.0	26.0	21.0	18.0	23.0	28.0	21.0
4	PD 544-C*	Painted..	6	Large.....	Glass	12.0	15.0	15.0	22.0	19.0	33.0	22.4	22.0	14.0	23.0
5	PD 544-C*	Painted..	6	Large.....	Glass	41.0	26.0	45.0	26.0	68.0	42.0	50.0	50.0	41.0	49.0
6	Laboratory water-wettable powder.....	Painted..	6	—	Glass	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	Deenat water-wettable powder.....	Painted..	6	—	Glass	100.0	100.0	100.0	100.0	100.0	100.0	97.3	98.2	98.5	76.7
8	Deenat water-wettable powder.....	Sprayed..	6	—	Glass	100.0	100.0	100.0	100.0	96.5	100.0	100.0	99.2	64.2	83.0
9	Deenat water-wettable powder and glue.....	Sprayed..	6	—	Glass	100.0	100.0	97.7	100.0	92.0	99.2	95.0	100.0	100.0	100.0
0	Controls.....	—	—	—	Glass	1.0	0.0	2.1	1.9	0.0	0.0	0.0	3.2	1.8	0.0
10	Ethyl alcohol.....	Sprayed..	6	Superfine.....	Glass	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	Ethyl alcohol.....	Painted..	6	Superfine.....	Glass	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12	HB-10†.....	Sprayed..	6	Oily surface, none.....	Wood	36.4	27.3	41.5	32.7	26.7	28.6	25.2	26.7	43.0	16.8
12	HB-10†.....	Sprayed..	11	None.....	Wood	0.0	2.6	0.0	0.0	0.0	0.0	0.0	2.4	0.8	0.9
12	HB-10†.....	Sprayed..	18	Large.....	Wood	34.2	10.7	3.0	8.1	7.0	—	—	—	—	—
12	HB-10†.....	Sprayed..	30	Large.....	Wood	80.0	—	—	—	—	—	—	—	—	—
13	Xylene†.....	Sprayed..	6	Medium fine.....	Wood	100.0	88.7	65.7	44.5	37.5	34.8	39.6	48.0	43.2	42.0
13	Xylene†.....	Sprayed..	11	Medium fine.....	Wood	100.0	68.7	54.4	24.2	13.6	6.8	4.2	4.6	12.6	17.2
13	Xylene†.....	Sprayed..	18	Medium fine.....	Wood	13.1	14.8	4.0	1.8	1.0	—	—	—	—	—
13	Xylene†.....	Sprayed..	30	Medium fine.....	Wood	7.9	—	—	—	—	—	—	—	—	—
14	Pelisol AR-60†.....	Sprayed..	6	Oily surface, few medium.....	Wood	35.3	36.8	35.6	18.8	50.0	39.8	52.5	27.9	15.0	18.2
14	Pelisol AR-60†.....	Sprayed..	11	Medium.....	Wood	100.0	99.2	88.0	98.4	64.6	34.5	52.0	92.3	38.4	79.0
14	Pelisol AR-60†.....	Sprayed..	18	Medium.....	Wood	25.5	9.2	10.7	6.7	25.3	—	—	—	—	—
14	Pelisol AR-60†.....	Sprayed..	30	Medium.....	Wood	16.0	—	—	—	—	—	—	—	—	—
15	Xylene + ethylene dichloride†.....	Sprayed..	4	Medium fine.....	Wood	80.8	91.3	62.3	85.1	86.3	74.2	23.0	54.1	56.8	35.7

*2% B-1956 + 3% Triton X-155 emulsifiers.

Table 7 (continued)

PANEL No.	SOLVENT OR FORMULATION	METHOD OF APPLICATION	AGE OF DEPOSIT IN DAYS	CRYSTALS	SURFACE	PER CENT MORTALITY 24 HOURS AFTER STATED EXPOSURE OF FLIES TO THE SURFACE									
						1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
15	Xylene + ethylene dichloride†	Sprayed..	15	Very fine and matted.....	Wood	100.0	99.1	100.0	100.0	100.0	88.7	85.8	91.2	94.9	99.2
16	Xylene + carbon tetrachloride†	Sprayed	4	Medium fine	Wood	100.0	100.0	99.3	71.2	75.2	46.8	27.8	66.2	31.4	24.1
16	Xylene + carbon tetrachloride†	Sprayed..	15	Very fine and matted.....	Wood	100.0	100.0	100.0	99.1	95.3	99.2	100.0	100.0	100.0	100.0
17	Xylene†	Sprayed	2	Medium fine	Wood	100.0	100.0	95.7	86.4	63.4	31.2	20.0	28.4	37.8	44.4
17	Xylene†	Sprayed..	15	Fine and matted	Wood	100.0	100.0	100.0	99.1	95.3	100.0	86.4	88.0	74.2	85.3
18	Xylene†	Sprayed..	3	Medium fine	Wood	100.0	100.0	88.6	64.4	25.4	13.6	6.4	58.2	6.7	14.9
18	Xylene†	Sprayed..	15	Medium fine	Wood	100.0	96.1	80.0	51.1	12.2	9.1	13.2	14.3	11.0	10.1
19	Xylene†	Sprayed..	30	Medium fine	Wood	100.0	100.0	96.0	93.2	77.7	78.7	48.5	69.0	71.5	75.2
20	PD 544-C*	Sprayed..	6	Medium fine	Wood	100.0	100.0	99.2	97.3	85.7	97.2	100.0	81.0	88.2	91.0
20	PD 544-C*	Sprayed..	11	Very fine and matted.....	Wood	100.0	100.0	100.0	100.0	100.0	100.0	99.3	100.0	100.0	100.0
21	PD 544-C*	Sprayed	6	Medium fine	Wood	100.0	100.0	100.0	96.1	100.0	100.0	97.1	79.2	84.3	88.3
21	PD 544-C*	Sprayed..	11	Very fine and matted.....	Wood	100.0	100.0	99.3	100.0	100.0	100.0	100.0	100.0	99.1	100.0
22	Xylene†	Painted..	2	Surface appearing wet; few medium fine..	Wood	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
22	Xylene†	Painted..	15	Fine and very fine.....	Glass	100.0	100.0	100.0	100.0	100.0	100.0	99.8	97.4	100.0	94.8

* 2% B-1956 + 3% Triton X-155 emulsifiers.

† 5% Atlox 1045-A emulsifier.

‡ 10% Triton X-100 emulsifier.

rapidly than the laboratory water-wettable powder formulation in which *Cherokee* clay is used as a diluent.

The three formulations in which *HB-40*, xylene, and *Velsicol AR-60* were solvents, and *Atlox 1045-A* was used as the emulsifier, had different degrees of bloom and wear. The first test period 6 days after treatment showed considerable degradation of the well-crystallized DDT-xylene deposit; in the other two formulations, little loss of toxicity was noted from the first through the tenth exposure. Examination under a microscope revealed no crystals present where *HB-40* had been used and very few where *Velsicol AR-60* was employed. Five days later, when these same surfaces were again tested in like manner, the xylene treatment had eroded severely, that containing *AR-60* had eroded slightly, and the *HB-40* treatment showed no toxicity and no bloom. The *HB-40* treatment then appeared dry, whereas in the first series of tests it had a wet appearance. A third test of only five series of exposures on the eighteenth day and examination of deposits proved the appearance of crystals upon the surface of the *HB-40* treatment. The xylene treatment indicated a continued slow, inconspicuous bloom, and the *AR-60* treatment a more noticeable bloom. By the time of the last test, on the thirtieth day, of but one cage of flies, the results suggested that the rate of bloom is directly proportional to the rate of volatilization of the solvent. Thus, in 30 days *HB-40* had only begun to permit the crystallization of DDT; xylene had apparently passed its peak of crystallization by the fifth day, and *Velsicol AR-60* by the eleventh day. Probably some of the DDT remains bound in the wood as a supersaturated or saturated solution in any of these solvents for periods much longer than those indicated here.

Further studies with xylene as a solvent, as indicated in table 7, lead to the belief that, if the desirable secondary bloom is to be obtained, the flies, or whatever device is used for seeding the surface, should be on the surface not later than the second day. Thus, the period of seeding a xylene treatment seems somewhat limited. If, however, we add to the xylene emulsion-concentrate about 20 per cent ethylene dichloride or carbon tetrachloride we find

that a deposit bearing DDT will react to the stimulus on the fourth day to produce a plainly visible heavy white crystalline mat of extremely small, fine crystals on the wood surface. Of all the seeded blooms, these and the ones produced by the *PD 544-C* treatments were the heaviest and most resistant to wear at a high level of toxicity. Of all the formulations except those made with water-wettable powder, the 1.62 per cent DDT solution in 95 per cent ethyl alcohol produced the most lethal and tenacious deposits on glass surface when either sprayed or brushed upon the surfaces. It produced the finest crystalline deposits, and its crystallization was the most rapid, fig. 8.

Microscopic study of all solution deposits on glass revealed that rarely was crystallization complete. Usually a few or many minute blobs of supersaturated solution persisted among the DDT crystals, fig. 12. On glass and, less noticeably, on wood the size of the DDT crystals was determined by the speed of crystallization which, in turn, was determined by the physical properties of the solvent, figs. 6-13; rapid crystallization produced crystals of minute size. This phenomenon was especially noticeable where surface treatments were seeded by fly activity at the proper time and crystallization was at once initiated at the innumerable sites of fly contact. Often it was noted that dust, dirt, and scratches stimulated the formation of crystals on glass, fig. 13.

Schmitz & Goette (1948) apparently showed the degree of penetration of DDT solutions into poplar wood. The opinion of the present writer is that the degree of penetration may be influenced by highly variable elements in the environment. For example, under a certain set of conditions it is possible that most of the DDT could be crystallized on the surface of the wood if the solvent is highly supersaturated when the surface is stimulated. Without the stimulation, much of the DDT could remain dissolved and held in the wood by the solvent. Certain components of wood have shown a visible influence upon the bloom; it has been observed that frequent bloom occurs on the soft part of the wood between the hard or resinous annual rings before a crystalline formation occurs on the annual rings. On certain pieces of



Fig. 6.—DDT crystallization from *PD 544-C* emulsion. $\times 40$. Crystals of DDT formed in solvents that evaporate slowly tend to be large, lie flat on the glass, and exhibit low luster and high resistance to erosion.



Fig. 7.—DDT crystallization from no. 9 oil on glass. $\times 40$. The large crystals are plainly visible to the unaided eye.

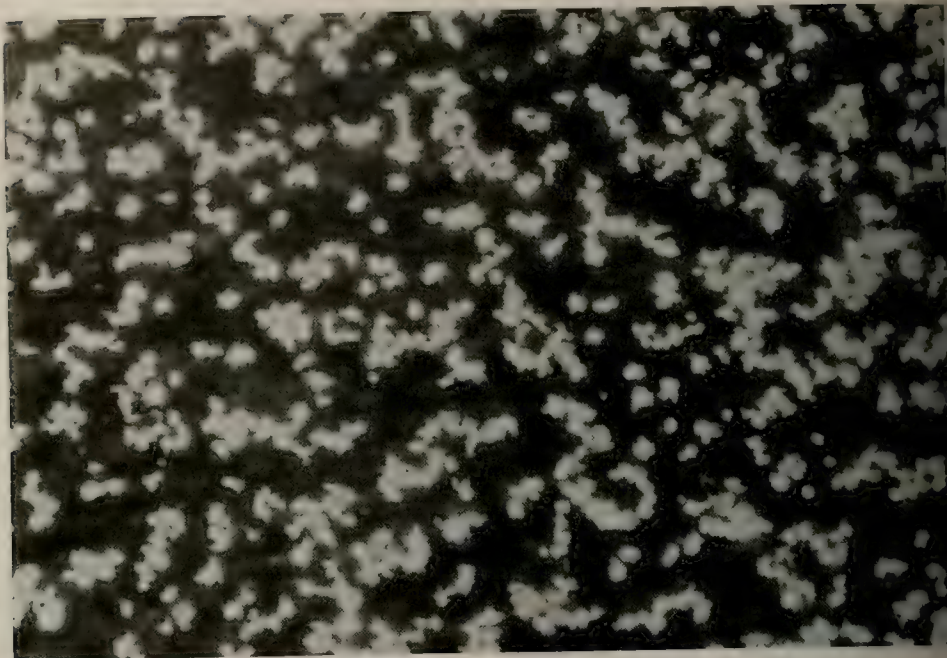


Fig. 8.—DDT crystallization from ethyl alcohol solution on glass. $\times 40$. The minute crystals not visible individually but only as dense hemispherical masses, have high toxicity and are resistant to erosion.

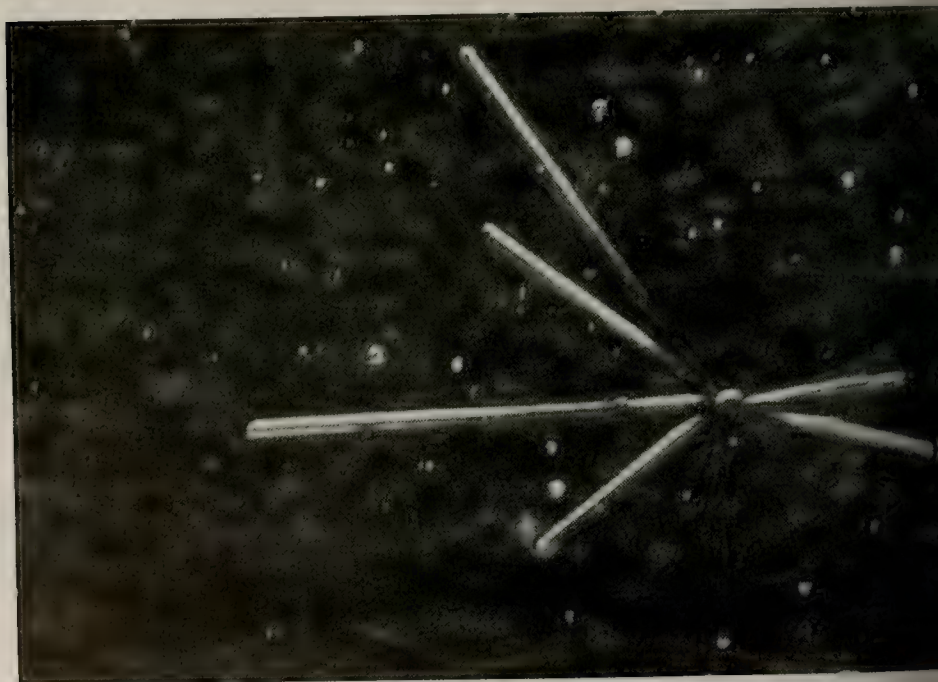


Fig. 9.—DDT in process of crystallizing from an *HB-40* solution. $\times 40$. The very large crystals, which lie flat upon the glass, are characteristic of very slow crystallization.

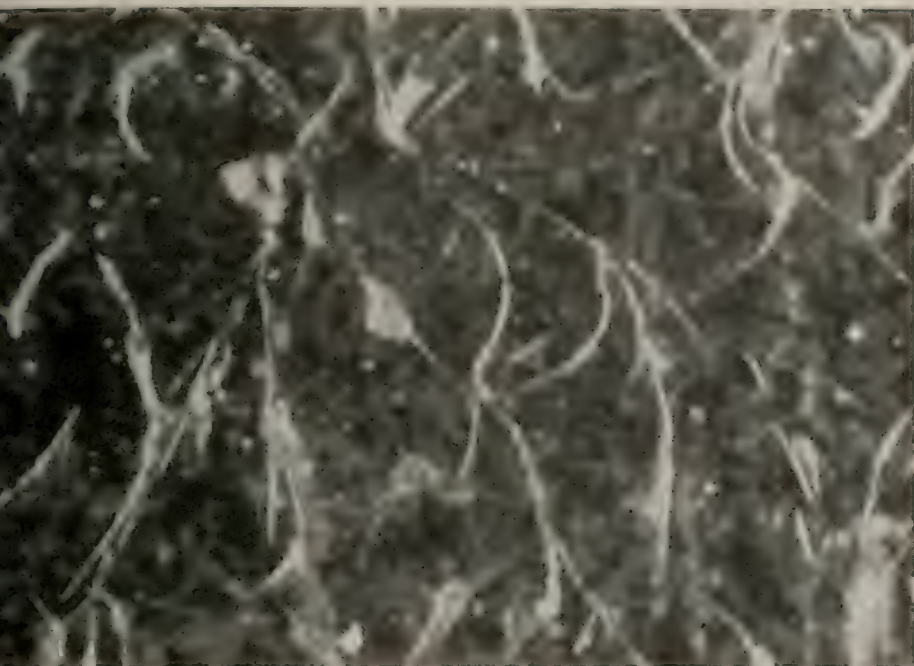


Fig. 10.—DDT crystallization from a *Velsicol AR-60* emulsion. $\times 40$. The crystals lying and forming a network on glass, have low toxicity and are resistant to erosion.

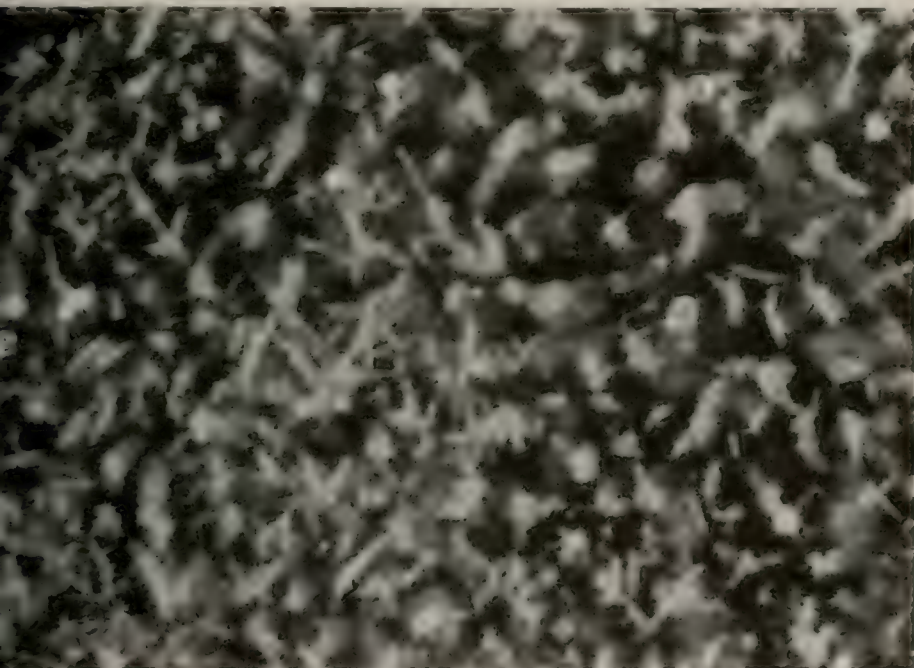


Fig. 11.—DDT crystallized from xylene emulsion on glass. $\times 40$. Network of crystals is similar to that from *Velsicol AR-60*, but the individual crystals are smaller.

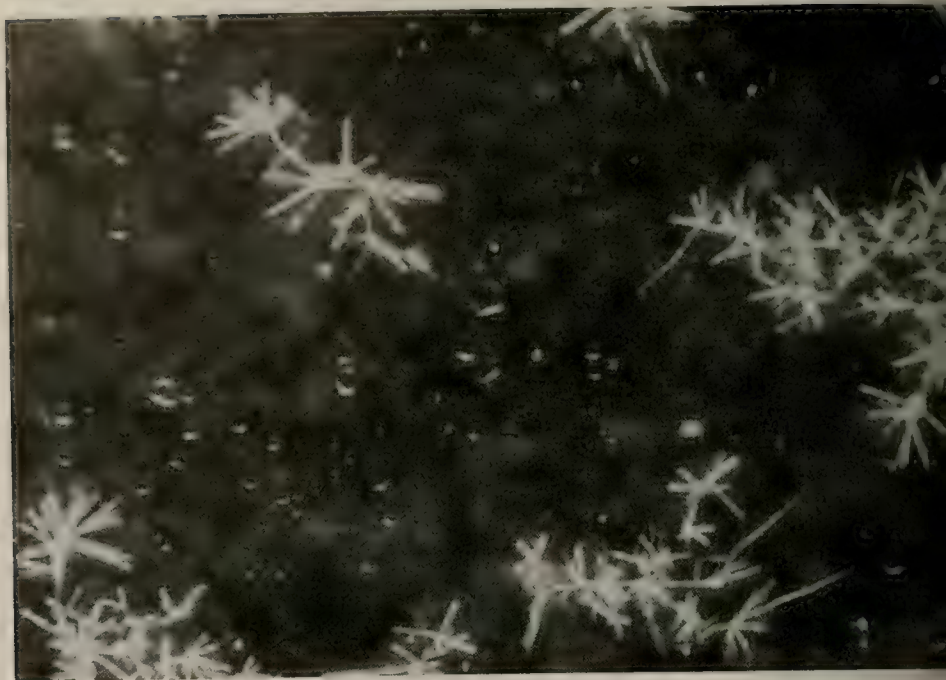


Fig. 12.—DDT in process of crystallizing from xylene solution on glass. $\times 40$. The xylene droplets (center of picture) among the crystals are susceptible to seeding by dust or fliers.

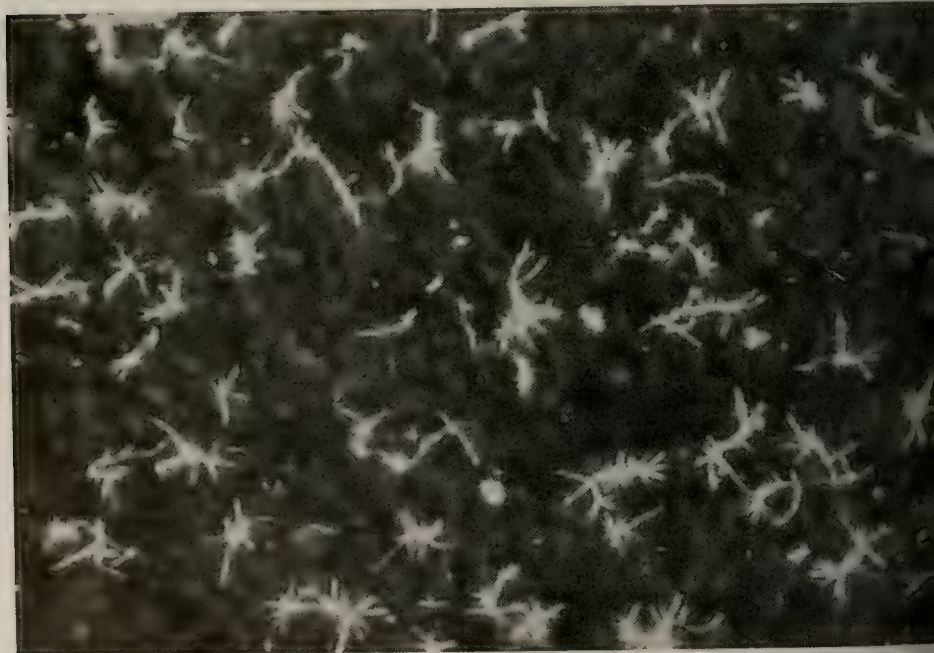


Fig. 13.—DDT in process of crystallizing from xylene solution. $\times 40$. The solution on glass shown here was seeded by dust, and crystallization started sooner than on glass shown in fig. 12.

ood, when a bloom occurs on the soft
rt of the wood, it does not occur
the annual rings. Thus, it seems that
netration or retention of DDT in the
ood depends upon the physical properties
the solvent and the particular piece of
ood used, in addition to environmental
ments.

Experiment 8: Fumigation Properties.—During the course of the studies,
difficulty was encountered with contamina-
tion of air in the room containing the fly-
cage. Investigation of this situation
revealed that the only possible source of
contamination was chlordan-treated sur-
faces at the opposite end of the room. Pre-
liminary tests indicated that *Toxaphene*,
lindane, *gamma D-3*, and DDT did not act as
fumigants to any noticeable extent; on the
other hand, chlordan and gamma hexa-
chlorocyclohexane seemed very toxic as
fumigants.

A study was made of the fumigation
action of chlordan and gamma hexachloro-
cyclohexane. Caged flies were placed in a
glass battery jar (11.6 liters capacity)
with 18 square inches of treated surface.

The top of the jar was sealed with a glass
plate smeared with a glycerine-bentonite
jell. Exposure times of six groups of flies
to the air in the jars were, respectively, 15,
30, 60, 120, 240, and 480 minutes. The
results of four replicates are shown in table
8. The losses of weight from the treated
surfaces were used to calculate the dosage
as milligrams per 1,000 cubic feet or
28.365 cubic meters. One mg. per 1,000
cubic feet is equivalent to 0.0353 mg. per
cubic meter. It was difficult to believe
that the calculated dosages actually existed
as a vapor, but rather existed as condensa-
tions or adsorptions over the entire inside
surface of each jar. It seemed conceivable
that there was a transfer of the toxicant
to the lipoid material in the insect's body
and consequently that a lethal concentra-
tion of the toxicants accumulated. These
data indicate the high order of toxicity
to house flies of vapors that were given
off from chlordan and hexachlorocyclo-
hexane. Chlordan and hexachlorocyclo-
hexane were compared with HCN, one
of the most toxic fumigants, and found to
be approximately 62 and 206 times as
toxic, respectively. Fly fumigation data

Table 8.—Mortality of house flies 24 hours after exposures of various periods to vapors
of chlordan and hexachlorocyclohexane residues.

TOXICANT	PER CENT MORTALITY 24 HOURS AFTER EXPOSURE OF					
	15 '	30 '	60 '	120 '	240 '	480 '
Chlordan.....	2.6	30.0	58.0	68.5	82.8	98.1
Chlordan.....	1.0	4.9	24.5	91.8	99.2	100.0
Chlordan.....	1.9	20.9	63.7	83.2	100.0	100.0
Chlordan.....	0.9	6.3	24.1	81.4	97.0	100.0
Chlordan.....	1.6	15.5	42.8	81.2	94.8	99.5
Average dosage calculated as mg. per 1000 cubic feet.....	1.51	3.04	6.07	12.14	24.28	48.56
Gamma isomer of hexachlorocyclohexane...	1.0	14.8	25.6	64.0	99.1	100.0
Gamma isomer of hexachlorocyclohexane...	1.9	6.1	25.0	71.4	95.2	100.0
Gamma isomer of hexachlorocyclohexane...	1.0	14.7	42.1	75.0	99.1	100.0
Gamma isomer of hexachlorocyclohexane...	0.0	4.1	20.0	54.1	88.2	99.2
Gamma isomer of hexachlorocyclohexane...	1.0	9.9	28.2	66.1	95.4	99.8
Average dosage calculated as mg. per 1000 cubic feet.....	0.52	1.06	2.11	4.22	8.44	16.88
Chlordan.....						0.0
Chlordan.....						1.1
Chlordan.....						0.0
Chlordan.....						1.9
Chlordan.....						0.75

' = minutes.

by Eddy (1929) were used in the calculations. The use of chlordan or hexachlorocyclohexane as residual fumigants within confined spaces is suggested by results of this experiment.

Experiments 9 and 10: Testing Periods.—To limit the reduction of surface toxicity by fly erosion, the number of test periods in these experiments was held to a minimum.

Table 9.—Mortality of house flies 24 hours after exposure to various treated surfaces subjected to several combinations of environmental elements. Surfaces were tested 2, 22, and 182 days after treatment with commercial emulsions of residual insecticides.

TOXICANT	EXPOSURE	SURFACE	MEAN PER CENT MORTALITY IN THREE REPLICATES		
			2 Days After Treatment	22 Days After Treatment	182 Days After Treatment
DDT	South outside...	Wood.....	99.70	11.90	0.00
	North outside...	Wood.....	99.43	31.07	0.00
	North sheltered...	Wood.....	99.07	46.53	8.07
	Inside.....	Wood.....	100.00	100.00	88.83
	South outside...	Glass.....	46.23	100.00	3.83
	North outside...	Glass.....	43.23	99.40	10.83
	North sheltered...	Glass.....	42.83	56.97	19.53
	Inside.....	Glass.....	45.33	35.63	21.17
	South outside...	Painted wood*	0.33	2.33	—
	Inside.....	Painted wood*	0.63	19.93	0.00
	South outside...	Cellutex.....	97.80	9.90	—
	Inside.....	Cellutex.....	96.67	97.27	36.30
	South outside...	Brick.....	74.97	6.33	—
	Inside.....	Brick.....	71.87	38.33	11.87
	South outside...	Concrete.....	0.97	0.00	—
	Inside.....	Concrete.....	1.30	0.80	0.00
	South outside...	Whitewash.....	2.30	4.07	—
	Inside.....	Whitewash.....	1.57	5.06	0.00
	South outside...	Galvanized...	57.73	8.47	—
	Inside.....	Galvanized...	38.80	26.57	67.43
Chlordan	South outside...	Wood.....	98.37	14.27	0.00
	North outside...	Wood.....	98.17	7.93	0.00
	North sheltered...	Wood.....	98.93	16.30	0.00
	Inside.....	Wood.....	98.77	14.17	0.00
	South outside...	Glass.....	98.97	15.93	0.00
	North outside...	Glass.....	99.10	22.70	0.37
	North sheltered...	Glass.....	99.43	10.80	0.30
	Inside.....	Glass.....	97.33	43.30	0.00
	South outside...	Painted wood*	69.13	2.92	—
	Inside.....	Painted wood*	68.30	3.93	0.60
	South outside...	Cellutex.....	85.97	7.10	—
	Inside.....	Cellutex.....	88.70	17.41	0.30
	South outside...	Brick.....	84.53	0.90	—
	Inside.....	Brick.....	83.35	3.17	—
	South outside...	Concrete.....	64.60	2.37	—
	Inside.....	Concrete.....	56.50	4.23	—
	South outside...	Whitewash.....	67.07	3.00	—
	Inside.....	Whitewash.....	76.23	29.37	—
	South outside...	Galvanized...	94.67	25.53	—
	Inside.....	Galvanized...	96.50	35.20	0.00
Rhothane D-3	South outside...	Wood.....	66.33	10.43	0.00
	North outside...	Wood.....	60.07	11.37	0.00
	North sheltered...	Wood.....	59.43	27.60	6.63
	Inside.....	Wood.....	58.60	19.07	12.00
	South outside...	Glass.....	58.23	13.27	0.00
	North outside...	Glass.....	70.90	16.43	0.60
	North sheltered...	Glass.....	73.57	40.40	7.60
	Inside.....	Glass.....	65.43	35.70	31.03

* Flat white wall paint containing vegetable oil vehicle.

Table 9 (continued)

TOXICANT	EXPOSURE	SURFACE	MEAN PER CENT MORTALITY IN THREE REPLICATES		
			2 Days After Treatment	22 Days After Treatment	182 Days After Treatment
Gamma isomer of hexachloro-cyclohexane	South outside...	Wood.....	94.23	0.70	0.00
	North outside...	Wood.....	97.17	3.63	0.33
	North sheltered	Wood.....	97.53	1.00	0.00
	Inside.....	Wood.....	98.33	31.97	1.57
	South outside...	Glass.....	99.13	0.43	—
	North outside...	Glass.....	97.00	0.70	—
	North sheltered.	Glass.....	98.66	9.23	0.27
	Inside.....	Glass.....	97.87	45.93	0.90
	South outside...	Painted wood*	61.70	12.33	—
	Inside.....	Painted wood*	60.37	32.33	0.00
	South outside...	Cellutex.....	72.63	3.60	—
	Inside.....	Cellutex.....	73.77	10.33	—
	South outside...	Brick.....	69.03	1.67	—
	Inside.....	Brick.....	90.67	5.20	—
	South outside...	Concrete.....	50.03	0.00	—
	Inside.....	Concrete.....	43.97	0.90	—
	South outside...	Whitewash...	89.00	1.13	—
	Inside.....	Whitewash...	86.90	9.30	—
	South outside...	Galvanized...	99.80	11.90	3.20
	Inside.....	Galvanized...	99.47	0.00	0.00
Toxaphene	South outside...	Wood.....	70.33	4.43	—
	North outside...	Wood.....	64.77	1.30	—
	North sheltered.	Wood.....	71.60	44.67	0.00
	Inside.....	Wood.....	71.13	63.90	0.93
	South outside...	Glass.....	99.37	22.47	0.00
	North outside...	Glass.....	98.90	6.37	0.00
	North sheltered	Glass.....	98.53	62.10	3.80
	Inside.....	Glass.....	98.33	84.37	5.27
Control	—	—	1.17	0.67	0.63
	—	—	1.57	—	—
	—	—	1.47	—	—
	—	—	0.57	—	—
Mean difference necessary for significance, 0.05 level.....			9.11	25.54	4.95
Mean difference necessary for significance, 0.01 level.....			21.11	33.66	6.58

* Flat white wall paint containing vegetable oil vehicle.

In experiment 9, only three test periods were used and in experiment 10 four test periods. If, at the end of 22 days in experiment 9, a material had lost its toxicity it was considered to be of little value as a residual insecticide in fly control on farms. If it proved to be toxic at the end of 22 days, it was considered for further testing at the 182-day test period. Any material that showed toxicity at the end of 182 days was regarded as very persistent and possessed of adequate residual kill properties for any practical application.

In experiment 10, 2-, 12-, 32-, and 152-day test periods were employed. Two-

and 12-day periods were used to obtain data on panels coated with materials having a short residual life. The 32-day period was used to measure materials with a satisfactory period of toxicity for most structural pest control purposes, and the 152-day period was used to obtain information needed on those materials of truly long residual activity such as those desirable for fly control on farms or those presenting a residue problem on foodstuffs.

Experiment 9: Field Persistence of Residues From Commercial Emulsions.—Five toxicants were applied

to eight surfaces—planed fir, glass, painted wood (1 month old), *Cellutex* (similar to *Celotex*), brick, concrete, whitewashed wood (1 month old), and galvanized iron—at a rate of 50 mg. per square foot, table 9. Treatments on wood and glass were exposed to various elements of the weather. Three replicates of each treatment on glass and wood were placed in situations on the South Farm of the University of Illinois so that one set was inside; another was outside on the south side of buildings exposed to all the elements; the third was on the north side of buildings; and the fourth was under a shelter that gave protection from sun and rain. The four positions may be described simply as the inside, the south exposure, the north exposure, and the sheltered. Surfaces other than glass and planed fir were placed in two positions—the south

outside exposure and the inside. The objective of this experiment was to obtain information on the persistence of the five toxicants on the eight surfaces under various conditions. A study of table 9 will reveal the insecticides that were found to be most persistent under various conditions and also the surfaces on which insecticides were retained the greatest length of time.

Experiment 10: *Field Persistence of Residues From a Standardized Formulation of Emulsions.*—The plan of this experiment was essentially the same as that of experiment 9. The variable of formulation was eliminated, and better-defined positions of exposure to the climatic elements were set up. Treated panels were exposed by means of suitable supports, fig. 14, on top of a flat-roofed



Fig. 14.—Securing treated panels to pipe rack for determining the effects of weathering upon toxicities of residues.

building. Some panels were secured to a pipe rack in north and south outside positions. Others were placed on racks beneath a shelter designed to keep out rain and sunshine. Still others were kept in the laboratory. The same solvent and emulsifying agent were used in all formulations. The emulsifiable concentrates contained 65 per cent xylene, 10 per cent *Triton X-100*, and 25 per cent by weight of the toxicant. These were diluted with water to give an emulsion containing 1 per cent of the insecticide. Incorporated with this experiment were tests with DDT water-wettable powder; it was hoped that such a formulation would overcome some of the surface hazards encountered with emulsions.

Experiments 9 and 10: Discussion.

—Results of these tests are shown in tables 9 and 10. DDT was the outstanding residual insecticide. *Rhothane D-3* was the next most persistent material, with *Toxaphene* a good third choice. Gamma hexachlorocyclohexane and chlordane were the least persistent. Probably one of the greatest hazards was dust. Dust particles falling upon treated surfaces introduced a variant, not measureable. Nevertheless, dust presents one of the conditions frequently found under field conditions.

Analysis of these data made it evident that differentiation among elements is difficult. Rain appeared by visual evidence and biological assay to be the prime element in the degradation of the residual deposits. The deposits that were exposed to rain were more persistent on hard impervious surfaces (glass and galvanized iron) than on porous surfaces (brick, fir wood, and *Gellutex*). On painted wood, concrete, and whitewashed wood the initial and residual toxicity of the insecticides to house flies was lower than on other surfaces. The deposit from 50 per cent DDT water-wettable powder gave promising results on all surfaces. At the end of 152 days, the DDT suspension deposits were significantly toxic on all inside surface treatments except whitewashed wood.

The emulsion containing *PD 544-C* and DDT that was used to obtain data in table 9 shows the typical high toxicity of the initial tests on wood; considerable losses were incurred as a result of

erosion and degradation by the twenty-second day of the test. Those panels with south exposure (exposed to all the elements) showed the greatest losses; those with north exposure (exposed to all elements except sunshine) showed approximately 20 per cent greater killing power. These losses may be accounted for by one or both of two possibilities: (1) direct sunlight or the heat produced by solar radiation; (2) rain driven onto the panels by a prevailing southwest wind. Wood panels sheltered from rain as well as sun exhibited about 15 per cent greater mortality to flies than the ones with north exposure. Wood panels placed within buildings retained their toxicity beyond the 22nd day and even to the 182nd day. The difference in toxicity between those wood panels held indoors and those in sheds where they were sheltered from external elements (sunshine and rain) might be assigned to one or both of two possibilities: wind erosion and dust accumulation found in the sheds.

The second series of tests (experiment 10) with uniform emulsions reveals no significant differences between those panels retained within the laboratory and those kept in a shelter constructed on top of a building. Both sites were relatively dust-free in contrast to the interior of the sheds used in the first test. In light of available information, it must be assumed that the real cause of degradation of the surfaces in the sheltered positions of the first series of tests (experiment 9) was dust accumulation and not wind erosion.

The glass panels treated with DDT emulsions may at first appear to offer somewhat contradictory evidence of toxicity unless the difference in solvents and emulsifiers used in the first and second series of tests is kept in mind.

In experiment 9, with a commercial *PD 544-C* emulsion of DDT on glass, the deposits and the test clearly showed that the rain, wind, or some other element found in the outside positions caused the DDT residue, a large part of which existed as a supersaturated solution in *PD 544-C* and emulsifier, to bloom or crystallize out. A microscopic comparison of the residues on the panels at the time of testing on the twelfth day revealed the presence of practically no supersaturated blobs

on the glass panels from the two outside positions in contrast to much supersaturated fluid on those inside, particularly those sheltered from all the elements, including the wind. By the 182nd day, however, the order of residual toxicity was reversed by the wear of the elements.

In tests with uniform emulsions (experiment 10) where xylene was the solvent, seeded crystallization occurred on

glass earlier (probably as a result of the initial fly action) than in experiment 9; that is, the xylene had probably slowly evaporated so that by the end of the first test period the blobs produced were easily crystallized when contacted by flies. There are other possible explanations for the high level of toxicity observed in the first two test periods. One is that the *Triton X-100* emulsifier containing some dissolved DDT

Table 10.—Mortality of house flies 24 hours after exposure to various treated surfaces subjected to several combinations of environmental elements. Surfaces were tested 2, 12, 32, and 152 days after treatment with standard laboratory emulsions of residual insecticides.

TOXICANT	EXPOSURE	SURFACE	MEAN PER CENT MORTALITY IN THREE REPLICATES			
			2 Days After Treatment	12 Days After Treatment	32 Days After Treatment	152 Days After Treatment
DDT	South outside...	Wood.....	99.07	14.47	3.67	—
	North outside...	Wood.....	99.73	16.90	7.03	—
	North sheltered...	Wood.....	100.00	93.33	99.07	—
	Inside.....	Wood.....	98.87	99.13	93.93	93.63
	South outside...	Glass.....	96.17	78.27	6.00	—
	North outside...	Glass.....	95.50	55.87	8.63	—
	North sheltered...	Glass.....	91.00	97.77	9.80	—
	Inside.....	Glass.....	96.77	86.23	26.10	7.10
	South outside...	Painted wood*	8.40	6.18	0.30	—
	Inside.....	Painted wood*	11.03	4.00	1.43	0.90
	South outside...	<i>Cellutex</i>	95.90	12.47	3.33	—
	Inside.....	<i>Cellutex</i>	93.50	99.37	61.60	36.23
	South outside...	Brick.....	97.00	28.10	2.97	—
	Inside.....	Brick.....	98.00	100.00	74.83	62.43
	South outside...	Concrete.....	10.17	3.23	—	—
	Inside.....	Concrete.....	7.17	2.57	0.33	0.00
	South outside...	Whitewash.....	13.33	2.40	—	—
	Inside.....	Whitewash.....	14.53	3.03	0.20	0.30
	South outside...	Galvanized.....	67.33	59.63	6.10	—
	Inside.....	Galvanized.....	79.70	100.00	92.70	53.07
Chlordan	South outside...	Wood.....	95.47	1.47	—	—
	North outside...	Wood.....	95.80	0.57	—	—
	North sheltered...	Wood.....	99.50	1.57	—	—
	Inside.....	Wood.....	97.67	7.63	2.00	1.70
	South outside...	Glass.....	100.00	0.27	—	—
	North outside...	Glass.....	100.00	1.30	—	—
	North sheltered...	Glass.....	100.00	88.37	5.10	—
	Inside.....	Glass.....	100.00	88.10	3.97	1.50
	South outside...	Painted wood*	37.43	0.87	—	—
	Inside.....	Painted wood*	41.43	6.43	—	—
	South outside...	<i>Cellutex</i>	73.00	1.47	—	—
	Inside.....	<i>Cellutex</i>	65.30	7.67	—	—
	South outside...	Brick.....	98.93	6.93	—	—
	Inside.....	Brick.....	94.80	7.10	—	—
	South outside...	Concrete.....	55.63	1.80	—	—
	Inside.....	Concrete.....	47.07	3.83	—	—
	South outside...	Whitewash.....	66.53	1.83	—	—
	Inside.....	Whitewash.....	46.40	11.43	4.93	0.30
	South outside...	Galvanized.....	91.23	1.53	—	—
	Inside.....	Galvanized.....	93.70	26.97	0.00	1.30

* Flat white wall paint containing vegetable oil vehicle.

NOTE: Emulsions were applied at the rate of 5 ml. of 1% toxicant per square foot. Each emulsifiable concentrate consisted of 25% by weight of toxicant + 10% *Triton X-100* + 65% xylene.

Table 10 (continued)

TOXICANT	EXPOSURE	SURFACE	MEAN PER CENT MORTALITY IN THREE REPLICATES			
			2 Days After Treatment	12 Days After Treatment	32 Days After Treatment	152 Days After Treatment
Gamma isomer of hexachloro-cyclohexane	South outside...	Wood.....	100.00	12.47	—	—
	North outside...	Wood.....	100.00	4.90	—	—
	North sheltered...	Wood.....	99.67	3.47	—	—
	Inside.....	Wood.....	100.00	27.80	0.77	2.17
	South outside...	Glass.....	98.67	0.75	—	—
	North outside...	Glass.....	100.00	3.83	—	—
	North sheltered...	Glass.....	100.00	11.83	0.00	—
	Inside.....	Glass.....	99.67	99.70	2.07	1.50
	South outside...	Painted wood*	68.07	8.60	3.30	—
	Inside.....	Painted wood*	65.10	28.60	3.90	—
	South outside...	Cellutex.....	92.80	26.17	2.13	—
	Inside.....	Cellutex.....	87.37	7.37	1.13	—
	South outside...	Brick.....	100.00	10.40	—	—
	Inside.....	Brick.....	99.40	7.13	—	—
	South outside...	Concrete.....	67.77	3.10	—	—
	Inside.....	Concrete.....	65.40	1.40	—	—
	South outside...	Whitewash....	85.43	3.07	—	—
	Inside.....	Whitewash....	74.37	19.17	—	—
	South outside...	Galvanized....	48.80	7.37	—	—
	Inside.....	Galvanized....	43.23	3.83	—	—
Rhothane D-3	South outside...	Wood.....	32.60	6.77	—	—
	North outside...	Wood.....	37.97	0.97	—	—
	North sheltered...	Wood.....	34.57	2.17	—	—
	Inside.....	Wood.....	36.27	17.47	20.43	13.73
	South outside...	Glass.....	87.67	99.73	9.50	—
	North outside...	Glass.....	84.93	99.43	24.47	—
	North sheltered...	Glass.....	80.40	94.97	10.57	—
	Inside.....	Glass.....	85.97	90.87	29.97	25.00
Toxaphene	South outside...	Wood.....	51.30	1.77	—	—
	North outside...	Wood.....	42.40	3.67	—	—
	North sheltered...	Wood.....	44.40	1.00	—	—
	Inside.....	Wood.....	46.37	7.60	6.13	0.63
	South outside...	Glass.....	100.00	0.63	—	—
	North outside...	Glass.....	100.00	1.70	—	—
	North sheltered...	Glass.....	100.00	100.00	74.70	—
	Inside.....	Glass.....	99.73	99.77	91.57	82.97
DDT as from a 50% water-wettable powder	South outside...	Whitewash....	100.00	14.07	0.60	—
	Inside.....	Whitewash....	100.00	99.67	55.4	14.90
	South outside...	Painted wood*	100.00	6.80	6.83	—
	Inside.....	Painted wood*	100.00	7.97	5.83	0.57
	South outside...	Galvanized....	100.00	95.87	1.43	—
	Inside.....	Galvanized....	100.00	100.00	95.80	89.20
	South outside...	Wood.....	94.80	9.33	4.97	—
	Inside.....	Wood.....	95.97	93.03	91.00	58.70
Control	—	—	1.27	0.80	0.70	0.00
	—	—	1.00	0.57	0.67	0.30
Mean difference necessary for significance, 0.05 level..			13.10	6.30	25.47	8.82
Mean difference necessary for significance, 0.01 level..			17.29	8.32	33.66	11.80

* Flat white wall paint containing vegetable oil vehicle.

NOTE: Emulsions were applied at the rate of 5 ml. of 1% toxicant per square foot. Each emulsifiable concentrate consisted of 25% by weight of toxicant + 10% Triton X-100 + 65% xylene.

acted as a contact poison. Another is that, previous to the first test, dust in the laboratory stimulated or seeded the drying deposit. The DDT deposits on glass or galvanized iron in all instances were more tenacious than those on porous surfaces such as wood, brick, and *Cellutex*, where erosion was significantly high. DDT on painted wood did not appear to be toxic either initially or residually. No doubt the DDT was absorbed into the paint and retained. There was no evidence in these tests that the DDT eventually bloomed, as would be expected if the solvent capacity of the oil paint were exceeded. On *Cellutex* and brick, the DDT residues were similar in longevity and erosion to those on wood. The degradation of DDT deposits was most evident upon whitewashed and concrete surfaces. In all probability the alkalinity of these substrates caused a dehydrohalogenation decomposition. DDT emulsions on galvanized iron exhibited high toxicity and longevity.

The residual longevity of the remaining four toxicants listed in tables 9 and 10 was influenced by the same external environmental degradants as was DDT, with a few exceptions that are discussed in the following paragraphs.

Chlordan-treated wood panels were little influenced by any external factors since greatest loss of chlordan was through volatilization or absorption. In the field test, where chlordan was formulated with no. 9 oil and emulsified with *Ailox 1045-A*, no erosion by rain or degradation by other elements was discernible. In experiment 10, with standardized formulations, the toxicity of chlordan on wood had declined to such a low level by the time of the first test after exposure to weathering that no conclusions were possible. In contrast, erosion of chlordan by rain was plainly evident on glass panels. When no. 9 oil (experiment 9) was used as the diluent, the residual toxic life of a chlordan deposit was at least twice as long as when a xylene formulation (experiment 10) was employed. Similarly, when *PD 544-C* was used as the solvent (experiment 9), the residual toxicity of a hexachlorocyclohexane deposit was longer than when a xylene was employed (experiment 10).

Gamma hexachlorocyclohexane also reacted to its environment in a manner

similar to the action of DDT, but hexachlorocyclohexane degraded rapidly out of doors or in strong wind currents. Most of its loss was attributed to its volatility.

Rhothane D-3 was significantly more tenacious on glass than on wood, and responded to its environment in much the same manner as did DDT.

Toxaphene lost its toxicity on wood much more rapidly than on glass panel held in the laboratory. Simple physical absorption of *Toxaphene* by the wood is suggested as an explanation.

Experiment 11: Formulation Studies.—The data obtained in the laboratory study of the persistence of oil solutions, emulsions, and suspensions are given in table 11. Studies of duration of residual toxicity were conducted to see if any on formulation was more persistent on the hazardous surfaces—whitewashed wood, concrete, and painted wood—that caused apparently rapid loss of toxicity. The results show that water-wettable powder were generally superior to the other formulations on all these surfaces.

The initial toxicity of oil solutions and emulsions of DDT, as evidenced by the data in table 11, was very low on whitewashed wood, painted wood, concrete, and unpainted wood, and very high on glass. The results here are similar to others in this study, which indicate that oil solutions or emulsions of DDT are low in toxicity on porous surfaces and very high on hard smooth surfaces, such as glass, if tested before crystals have started to form.

The second test period 7 days after treatment gave high fly mortalities on wood panels and lower on glass panel. The water-wettable powders of DDT were significantly more toxic on painted wood, whitewashed wood, and concrete than were the oil solutions or emulsion. Even with the wettable powder the alkalinity of the whitewash and concrete must have reached the DDT to cause a decline in the toxicity. This action was probably accomplished through adsorbed water. On painted wood the toxicity decreased without any apparent reason; a possible explanation is that the oils in the underlying paint were capable in some manner of penetrating the wettable powder and dissolving away the DDT. On glass an

Table 11.—Mortality of house flies 24 hours after exposure to various surfaces treated with oil solutions, emulsions, and water-wettable powders of DDT and chlordan. Flies were exposed to surfaces 1, 7, and 45 days after the surfaces had been treated.

RESIDUAL INSECTICIDE FORMULATION	SURFACE	MEAN PER CENT MORTALITY IN THREE REPLICATES		
		1 Day After Treatment of Surface	7 Days After Treatment of Surface	45 Days After Treatment of Surface
DDT oil solution	Whitewash.	0.0	0.6	0.0
	Painted wood*. . .	4.9	3.5	2.2
	Concrete.	0.0	1.7	0.0
	Glass.	100.0	77.9	75.8
	Wood.	10.7	100.0	99.4
DDT emulsion	Whitewash.	0.6	4.2	0.4
	Painted wood*. . .	1.1	2.6	0.0
	Concrete.	0.6	1.2	0.0
	Glass.	95.5	35.1	24.6
	Wood.	3.5	98.6	94.4
DDT suspension	Whitewash.	100.0	92.9	32.9
	Painted wood*. . .	100.0	28.0	2.5
	Concrete.	99.7	41.2	12.2
	Glass.	100.0	100.0	91.2
	Wood.	98.3	96.6	83.2
Chlordan oil solution	Whitewash.	95.7	32.9	0.3
	Painted wood*. . .	4.5	8.1	0.0
	Concrete.	16.8	5.8	0.0
	Glass.	100.0	23.8	2.2
	Wood.	99.4	34.5	1.0
Chlordan emulsion	Whitewash.	84.3	31.6	6.6
	Painted wood*. . .	93.0	1.6	0.3
	Concrete.	42.7	4.8	0.0
	Glass.	99.3	81.9	2.8
	Wood.	100.0	27.0	0.3
Chlordan suspension	Whitewash.	69.0	27.5	2.5
	Painted wood*. . .	92.9	12.1	4.2
	Concrete.	41.0	7.1	0.5
	Glass.	100.0	5.2	0.5
	Wood.	100.0	37.9	1.9
Control	—	0.60	1.90	0.00
	—	1.00	0.90	0.90
Largest difference necessary for significance, 0.5 level.		5.53	3.78	8.46
Largest difference necessary for significance, 0.1 level.		7.37	5.04	11.26

* White site wall paint containing vegetable oil vehicle.

and panels the toxicity of the wettable powders remained at a high level.

There was no important advantage in using a chlordan water-wettable powder on surfaces where DDT water-wettable powder was superior to the DDT emulsion and oil solutions. In fact, upon glass the chlordan water-wettable powder was significantly less effective than were the oil solutions and emulsions. The reason for the short residual action of the chlordan

water-wettable powder on glass may have been associated with the greater surface area of the finely divided powder, responsible for a rapid rate of loss through evaporation. The greater loss of toxicity from the glass panels treated with chlordan oil solutions, in contrast to the emulsions, was perhaps influenced by an increase in surface area produced by a continuous film. The emulsions left a discontinuous film, which was not so subject to evaporation.

In addition, the emulsions had an emulsifier of high vapor pressure, which retards chlordan evaporation.

Experiment 12: Laboratory Persistence of Deposits.—A plan was made to test more fully the residual properties of the three most promising toxic residual materials. At frequent intervals during a 31-day period, house flies were exposed for 15-minute periods to panels treated with DDT and gamma hexachlorocyclohexane and for 60-minute periods to panels treated with chlordan. The results are shown in table 12. The order of persistence on wood or glass was, from the most persistent to the least, DDT, chlordan, and gamma hexachlorocyclohexane. The suspension of hexachlorocyclohexane retained its toxicity at a high level for 10 days; then its toxicity declined rapidly. Chlordan lost its toxicity gradually through the test period, whereas DDT emulsion on wood seemed to increase in effectiveness.

The lower toxicity exhibited by the

emulsion of DDT and *PD 544-C* on glass than on wood from the first day to the last is typical of DDT residues in which a slowly volatilizing solvent is used and crystallization is progressive. In other words, the frequent exposure of flies to these surfaces did not permit sufficient supersaturated fluid to accumulate, which is essential for the production of high toxicity residues composed of minute crystals. Again, a physical law determining crystal size was responsible for the toxicity attained. The number of crystals per unit mass is directly proportional to the rate of crystallization, which is dependent upon the degree of supersaturation. Blooming of DDT on wood occurred between the second and sixth days and produced a residue that remained toxic throughout this experiment.

The thick white residue of the gamma hexachlorocyclohexane water-wettable powder was slightly more toxic and persistent when applied to glass than to wood. The longevity of the chlordan and hexa-

Table 12.—Mortality of house flies 24 hours after exposure to wood and glass panels treated with DDT, hexachlorocyclohexane, and chlordan. Flies were exposed to treated surfaces at designated periods of time after the surfaces had been treated.

INSECTICIDE	DEPOSIT OF TOXICANT IN MG. PER SQUARE FOOT	SURFACE	REPLICATE NO.	PER CENT MORTALITY 24 HOURS AFTER EXPOSURE TO SURFACE STATED NUMBER OF DAYS AFTER TREATMENT OF SURFACE								EXPOSURE TIME MINUT
				1	2	4	6	10	12	24	31	
DDT emulsion	50	Wood	1	37	40	57	93	91	100	100	100	15
	50	Wood	2	49	48	60	96	81	75	85	100	15
	50	Wood	3	21	49	97	100	100	100	100	100	15
			Mean	35.7	45.7	71.3	96.3	90.7	91.7	95.0	100.0	—
	50	Glass	1	46	27	18	22	20	16	22	12	15
	50	Glass	2	76	24	19	15	15	13	12	13	15
	50	Glass	3	56	31	19	27	30	17	16	15	15
			Mean	59.3	27.3	18.7	21.3	21.7	15.3	16.7	13.3	—
	50	Wood	1	99	98	54	74	56	12	6	2	15
	50	Wood	2	100	96	65	86	43	17	7	3	15
Gamma isomer (5.2 per cent) hexachlorocyclohexane in a water-wettable powder	50	Wood	3	94	94	66	77	40	16	10	2	15
			Mean	97.7	96.0	61.7	79.0	46.3	15.0	7.7	2.3	—
	50	Glass	1	100	100	100	100	84	71	21	8	15
	50	Glass	2	100	100	100	100	100	81	16	4	15
	50	Glass	3	100	100	100	100	90	86	10	0	15
			Mean	100.0	100.0	100.0	100.0	91.3	79.3	15.7	4.0	—
	50	Wood	1	96	92	75	69	62	54	19	15	60
	50	Wood	2	98	95	80	77	60	33	22	6	60
	50	Wood	3	92	88	57	54	50	18	17	11	60
			Mean	95.3	91.7	70.7	66.7	57.3	35.0	19.3	10.7	—
Chlordan emulsion	50	Glass	1	100	100	52	52	34	19	9	0	60
	50	Glass	2	100	100	52	55	33	25	14	3	60
	50	Glass	3	100	100	74	67	45	17	17	7	60
			Mean	100.0	100.0	59.3	58.0	37.3	20.3	13.3	3.3	—
	50	Wood	1	96	92	75	69	62	54	19	15	60
	50	Wood	2	98	95	80	77	60	33	22	6	60

chlorocyclohexane residues was nearly equal. Chlordan seemed slightly more lasting on wood, and hexachlorocyclohexane lasted longer on glass.

In this particular experiment, table 12, chlordan was of about equal effectiveness on wood and on glass, while in most of the previous work the chlordan emulsion residue on glass gave more lasting toxicity than on wood. If an explanation of these results is desired, it might be found in the difference in the composition of the wood panels or the environment in which the panels were held. The cause of the degradation of chlordan on glass was attributed to dust and debris that accumulated upon the oily surface. In the experiment described above, dust and debris left on the surface by the flies may have been more important than that floated in by air currents. Not only will dust and dirt mask the chlordan, but may assist evaporation by increasing the evaporation area just as with water-wettable powder (experiment 11). It is not beyond reason to believe that the chlordan-treated glass surface was roughened by the fly contacts of the frequent exposures, resulting in greater surface area for evaporation. Also, the higher initial toxicity of chlordan-treated panels suggests a greater loss incurred by physical contact of the flies.

Experiment 13: Laboratory Study of DDT Emulsion on Glass and Wood.—The results of experiments summarized in table 12 seemed to indicate some peculiar properties of the initial toxicity of DDT emulsions on glass and wood. Another experiment was undertaken to broaden the scope of the investigation. This involved a closer study of the initial toxicity periods. Consequently, data were obtained from deposits of DDT that were

less than 1 day old. The results obtained, summarized in table 13, disclose the "blooming out" (crystallization of DDT on the surface) period of DDT on wood and reveal in the treatment on glass the loss of toxicity that occurred as the emulsion dried.

In this experiment, as in previous tests, no toxic bloom of fine powdery crystals occurred on glass, since fly stimulation and seeding of surface were too frequent to permit the accumulation of supersaturated solvents. Consequently, there was a gradual formation of large crystals of low toxicity. The greatest fly mortality from exposures to glass panels occurred before any DDT crystals were found; the opposite was true in the case of DDT emulsions on wood. Besides the seeding action by flies, many environmental components may influence the rate and kind of DDT bloom to appear on a surface. The same solvent may yield large crystals one day, and the next day, when the temperature is higher and air movements greater, it may produce small crystals.

Experiment 14: Approximate Residual Toxicity of Several New Insecticides to the House Fly.—Several new insecticides that have recently come under study are briefly considered here and compared with DDT and chlordan. Ten per cent solutions of *Marlate* (+,4'-dimethoxy-diphenyl trichloroethane), *F4* (diethyl *p*-nitrophenyl phosphate), *Pyrenone* (actually 10 per cent piperonyl butoxide and 0.5 per cent pyrethrins), *118* (1,2,3,4,10,10-hexachloro-1:4, 5:8-diendomethano-1,4,4a,5,8,8a-hexahydronaphthalene), parathion (diethyl *p*-nitrophenyl thiophosphate), heptaklor 1 (or 3a), 4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene, and 497 (oxygen

Table 13.—Mortality of house flies exposed 15 minutes to wood and glass panels at stated intervals after treatment of panels with 1 per cent DDT emulsion.

DEPOSIT OF DDT IN MG. PER SQUARE FOOT	SUR- FACE	REPLI- CATE	PER CENT MORTALITY 24 HOURS AFTER EXPOSURE TO SURFACE STATED PERIOD OF TIME AFTER TREATMENT OF SURFACE						
			4 Hours	8 Hours	1 Day	3 Days	5 Days	17 Days	24 Days
50.....	Wood	1	4.1	13.4	29.0	100.0	100.0	100.0	100.0
50.....	Wood	2	3.9	14.5	47.5	100.0	100.0	100.0	100.0
50.....	Glass	1	100.0	59.0	36.0	29.1	21.9	22.0	15.9
50.....	Glass	2	100.0	66.0	58.0	75.0	28.0	21.6	12.1

analogue of 118) in *Velsicol AR-60* (methylated naphthalenes) were sprayed in triplicate upon glass and wood panels to produce deposits of 50 mg. per square foot. Flies were exposed for 30-minute periods to these panels each week until the toxicants had degraded to a low level. One set of three panels of wood and glass was exposed to direct sunlight and wind but protected from rain; a similar set was kept in the laboratory.

Table 14 was designed to help evaluate the residual activities of the toxicants in periods of weeks needed to degrade a deposit to 50 per cent of its initial toxicity.

Table 14.—Approximate number of weeks required for residual insecticides to degrade to 50 per cent of their initial toxicity to house flies. Flies were exposed 30 minutes to each panel which had been treated with insecticide at the rate of 50 mg. per square foot of treated surface.

MATERIAL DISSOLVED IN <i>Velsicol AR-60</i>	OUTSIDE		INSIDE	
	Wood	Glass	Wood	Glass
<i>Marlate</i>	1.5	1.0	4.5	2.0
<i>V4</i>	1.0	1.5	7.5	14.5
<i>Pyrenone</i>	0.5	0.5	2.5	4.5
DDT.....	4.0	2.0	12.0	5.5
118.....	1.0	1.0	5.5	1.5
Parathion.....	0.5	0.5	1.5	2.0
Heptaklor.....	1.5	1.0	5.5	1.5
Chlordan.....	1.0	1.0	5.0	2.0
497.....	—	—	10.0	7.0

The residual values of the volatile toxicants in particular were extended by the relatively nonvolatile solvent, *Velsicol AR-60*. Experiments with *Pyrenone* in xylene gave a 50 per cent degradation value on glass in only 1.25 weeks; *Pyrenone* in *Velsicol AR-60* required 4.5 weeks for 50 per cent degradation. Similarly, chlordan in xylene had a 50 per cent degradation value on wood in 2 weeks; chlordan in *Velsicol AR-60* required 5 weeks in the experiment described above to sink to the same degradation value. The same kind of solvent effect was noted in experiments described earlier in this study. Undoubtedly there are, among the insecticides listed in table 14, toxicants that would serve well as substitutes for DDT when house-fly tolerance for DDT becomes too high to effect practical control.

SUMMARY

DDT, gamma hexachlorocyclohexane, chlordan, *Rhothane D-3*, and *Toxaphene* were applied on various surfaces and exposed to different environmental conditions in several experiments to determine their residual toxicities to the house fly, *Musca domestica* Linnaeus. The toxicities of the residues were determined by exposing the flies in specially constructed exposure cages to the treated surfaces for certain periods of time and holding the flies for a 24-hour mortality count.

The conclusions for the experiments herein reported are as follows:

1. DDT and gamma hexachlorocyclohexane were initially the most toxic compounds. The other three materials were, in order of their diminishing toxicity, chlordan, *Rothane D-3*, and *Toxaphene*.

2. Hexachlorocyclohexane gave the most rapid knockdown, followed by DDT, *Rhothane D-3*, chlordan, and *Toxaphene*.

3. Degree of coverage of surface affected mortality more than the dosage variations or uneven distribution of DDT.

4. A wall coat containing 5 per cent DDT (formulated from a 25 per cent DDT emulsifiable concentrate) was nearly as effective on wood as 50 per cent water-wettable DDT powder.

5. When DDT water-wettable powder was applied at different dosages to glass, a dosage mortality relationship was not evident above 12.5 mg. toxicant per square foot; a dosage range of 12.5 to 200.0 mg. resulted in nearly 100 per cent mortality. Below 12.5 mg. a typical sigmoid dosage-mortality curve was obtained.

6. In fly-erosion tests, there was little significant difference in fly mortality among 10 cages exposed successively to the same deposit of 50 mg. DDT per square foot.

7. Fly erosion was noticeable in tests with *Deenate* water-wettable powder on glass and xylene-DDT, *Velsicol AR-60*-DDT, and *HB-40*-DDT emulsions on wood, except when secondary blooming occurred.

8. Secondary or seeded blooms that occurred with certain formulations were very toxic and resisted fly erosion. On wood, those DDT emulsion formulations containing *PD 544-C* or xylene (with either ethyl-

ene dichloride or carbon tetrachloride) as the solvents produced exceedingly heavy mats of very fine crystals of high toxicity when seeded by fly activity. Bone glue 5 per cent, added to *Deenate* water-wettable powder improved tenacity. DDT, 1.26 per cent, in 95 per cent ethyl alcohol when applied to glass produced a deposit of extremely fine crystals of high toxicity and tenacity.

9. DDT-xylene emulsion deposits on glass or wood when seeded early (within 2 days after application) produced a fairly effective secondary bloom.

10. High toxicity and tenacity of deposits were associated with the fineness of DDT crystallization upon the surface.

11. No difference in toxicity or tenacity of deposits could be attributed to the method of application (spraying or painting).

12. Vapors from gamma hexachlorocyclohexane were about three times as toxic to flies as those from chlordan; both were extremely toxic as fumigants. The fact that toxic vapors are given off from chlordan and hexachlorocyclohexane deposits accounts for their short-lived residual action on exposed surfaces.

13. Solvents of low volatility increased the residual toxicity of the more volatile insecticides.

14. DDT was the most persistent insecticide tested. The residual toxicity of

DDT emulsions was better indoors on porous surfaces, such as wood, brick, and *Cellutex*, than on glass and galvanized iron. Out of doors, residues were more persistent on the nonporous glass and galvanized iron panels.

15. The order of persistence of the residual treatments was, from the most to the least, DDT, *Rhothane D-3*, *Toxaphene*, chlordan, and hexachlorocyclohexane.

16. The oil solutions and emulsions of the chlorinated hydrocarbons were relatively nontoxic to flies when applied to whitewash, painted wood, and concrete. Water-wettable powders produced effective residual deposits on these same three surfaces.

17. Sunshine, rain, and wind were found to be significant climatic factors in the degradation of the residual surface toxicities of the materials tested. Wind was apparently the least significant of the three.

18. With a few exceptions, when DDT emulsions were applied to wood, the toxicity increased as the DDT "bloomed out"; when the emulsions were applied to glass, the toxicity decreased as the emulsions dried and crystals formed parallel to the glass surface.

19. In a study on newer insecticides, *V4* and 497 on wood and glass produced residues of significant longevity with high toxicity. Other materials tested were less persistent.

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HARLOW B. MILLS, *Chief*

Effect of
Permanent Flooding
in a River-Bottom Timber Area

LEE E. YEAGER



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This paper is a contribution from the Section of Forestry.

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In the Calhoun County, Illinois, study area, permanently flooded in 1938, pin oaks and other tree species having durable heartwood characteristically lost their branches and later their sapwood, leaving standing skeletons of heartwood.

Effect of Permanent Flooding *in a River-Bottom Timber Area*

LEE E. YEAGER *

WATER impoundments, varying from simple fish ponds to the vast programs now being sponsored by the United States Corps of Engineers and the Bureau of Reclamation, involve many changes in the American landscape. Practically every major stream and hundreds of smaller ones have been or, if present proposals are consummated, will be affected by dams erected for power development, channel improvement, flood and erosion control, and other purposes. The environmental effects inherent in this nation-wide program are potentially of great importance to wildlife, inland fisheries, bottomland forests, and agriculture.

One of the problems associated with stream damming and resultant impoundments is that of flooded timberland. On many projects, especially where public funds are involved, the areas to be flooded are cleared of trees and brush. On others, clearing may be done only partly or not at all, because of shortage of funds, or because of bad weather, high water, or other reasons. Flood-killed timber is generally considered by the public as unsightly, and complaints concerning it may be strong. Dead trees that reach navigable streams after falling offer certain hazards to shipping, commercial fishing, and other enterprises associated with inland waterways. Therefore, whether from the standpoint of aesthetics or economics, flood-killed timber is a problem, and one

having a strong probability of increasing in importance.

The objective of the study on which the present report is based was to determine the rate of flooding mortality in various Mississippi River valley tree species and the rate and effect of tree fall; in the course of the study, brief consideration was given to plant and animal succession following the death of timber stands. The report covers principally the period beginning in September, 1939, and ending in October, 1946.

ACKNOWLEDGMENTS

My obligations for assistance during this investigation are many. I am indebted, first of all, to the late Dr. Theodore H. Frison, former Chief of the Illinois Natural History Survey, who proposed the study. To Dr. Leo R. Tehon, during part of the study period, Acting Chief of the Natural History Survey, and to Dr. Gustav A. Swanson, formerly with the Fish and Wildlife Service, I owe thanks for the co-operative arrangement wherein I was permitted to complete field observations. Dr. Tehon aided in planning the investigation and Mr. G. H. Boewe, also of the Survey staff, assisted with initial field work. Dr. Cornelius H. Muller, while with the Natural History Survey as a botanist, made the detailed vegetation map on which later work was based. For data used in preparing fig. 5, I am indebted to the St. Louis District, Corps of Engineers, Department of the Army. Several wildlife specialists of the Natural History Survey or co-operating organizations gave valuable help: Mr. Charles S. Spooner, Jr., was of much assistance in mapping; Mr. Frank C. Bellrose, Dr.

* Formerly Forester, Illinois Natural History Survey, Urbana, Illinois. Since May, 1945, with the United States Fish and Wildlife Service; present station, Leader, Colorado Co-operative Wildlife Research Unit, Colorado Agricultural and Mechanical College, Fort Collins, Colorado. The major portion of the investigation on which the present paper is based was made while the author was employed by the Natural History Survey. Completion of the study was accomplished through a co-operative arrangement between the Survey and the Fish and Wildlife Service.

Ralph E. Yeatter, Mr. Harry G. Anderson, Mr. Charles McGraw, and Mr. Willet N. Wandell provided numerous records and were helpful in other ways; and Mr. Robert G. Rennels made careful analysis of food-habits material. Mr. Carl Pohlman, a resident of Calhoun County, gathered valuable records on the fur take. Mr. James S. Ayars, Mr. Robert E. Hesselshwerdt, and Dr. H. H. Ross, editor, photographer, and systematic entomologist, respectively, of the Illinois Natural History Survey, are responsible for most of the photographs used here as illustrations. Mr. Ayars' assistance with editorial problems is gratefully acknowledged.

AREA STUDIED

Detailed work forming the background for the present report was done on the Pere Marquette Wildlife Experimental Area, locally known as Calhoun Point, in Calhoun County, Illinois, fig. 1. Calhoun

Point was formed by the confluence of the Mississippi and Illinois rivers.

At other than flood periods, previous to 1938, the 2,200-acre Pere Marquette area, roughly 1 by 4 miles, was characterized by numerous wooded ridges, flats, and wet-weather sloughs, several small lakes, a number of small marshes, and the margins of two large rivers. In June, 1938, gates of the recently completed Alton Dam, 20 miles downstream on the Mississippi River, were closed for the first time. This closure resulted in flooding several hundred acres of the area, normally land. Although the gates were opened a few times after June, 1938, the higher than normal water level that prevailed through much of the 1938 growing season, fig. 5, was sufficient to affect plant species sensitive to flooding.

By the summer of 1939, 600 acres (27 per cent) of the area were permanently inundated; 1,600 acres (73 per cent) lay above pool level, which was 15.3 feet

ILLINOIS STATE NATURAL HISTORY SURVEY



Fig. 1.—Air view of Calhoun Point, Calhoun County, Illinois, May 1938, prior to flooding.

at Grafton, 2 miles downstream. Prior to the Alton impoundment, annual fluctuation of the Mississippi and Illinois rivers in the locality varied from subgage lows to floods exceeding 25 feet. Even after the impoundment, severe floods occurred in 1943 and 1944 and a lesser flood in 1945. Permanent flooding increased the average summer water stage by about 3 feet. Maximum elevation on the area before impoundment was 10 feet; at pool level, after impoundment, the highest ridges were only 7 feet above the water surface. These figures indicate the very low relief of the Pere Marquette area.

STUDY PROCEDURE

Basic to the work reported here was a detailed vegetation map of the area prepared by Cornelius H. Muller while with the Natural History Survey's Section of Applied Botany and Plant Pathology. Muller did his field work between February 8 and June 11, 1938, shortly before initial flooding of the area was begun. In mapping the area, he established 11 transects, each 50 feet wide, that varied in length from 600 feet to 1.1 miles and totaled 5.9 miles.

Muller established the transects after he had made a general reconnaissance map of the many minor vegetation types distinguishable. He did not space the transects uniformly or orient them parallel with each other, but laid them out to cross as many as possible of the water channels and sloughs then present on the area and to traverse in a representative way as many as possible of the vegetation types.

He mapped the transects in such detail as to show the location of all trees, all large shrubs, and most of the herbaceous plant areas within them, recording species (substantiated by specimens deposited in the Illinois Natural History Survey herbarium), diameters of trees, sizes of shrubs, and density of herbaceous cover.

The location of six transects, 1, 2, 6, 7, 8, and 11, totaling 3.5 miles, is shown in fig. 2. These transects constitute the sample used as a basis for the present paper.

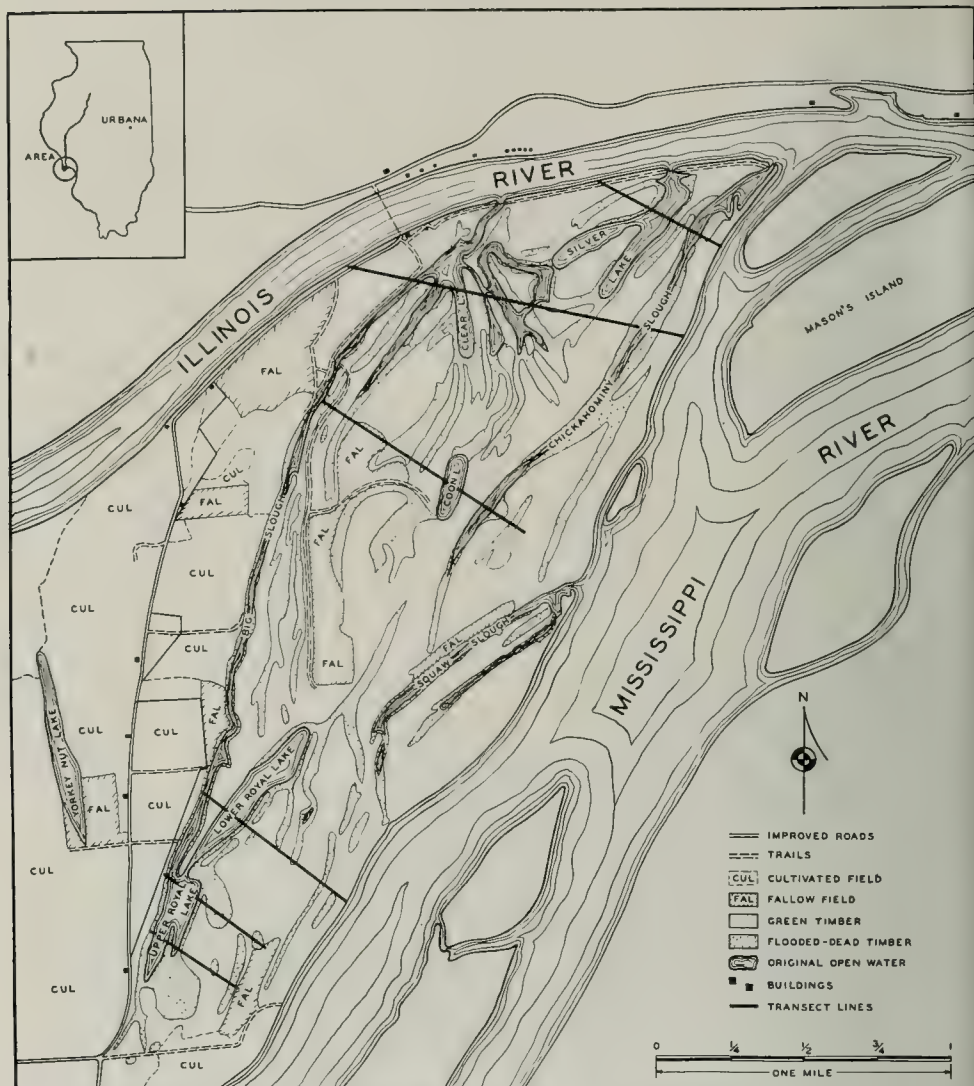
Active field work on the effect of flooding was begun in September, 1939, about

3 months after the date of permanent inundation. (The Alton Dam had been closed during the summer and a part of the fall of 1938, fig. 5.) The first records taken by the writer were before any of the trees had died, although the pin oaks and a few trees of other species showed effects of an abnormally high water stage.

In the six sample transects, 1, 2, 6, 7, 8, and 11, each living tree and shrub, regardless of species, size, or condition, was tagged for future inspection, except in pure stands of maple or elm on land, or in large clumps of waterprivet or buttonbush in water, where only every second, third, or fifth tree or shrub was tagged. Markers or tags were of 14-gage galvanized sheet metal, about 1 by 2 inches in size, each perforated at one end, and numbered consecutively. Attachment was by means of sixpenny galvanized nails, at a height of about 4.5 feet. In each transect the tags faced one direction, always that opposite to the direction of progress, thus facilitating both attachment and relocation. Transects were marked at each end and at varying intervals by appropriately numbered signs.

Records made at the time tags were attached and at all succeeding inspections were kept on the same form. At the first inspection, made when tags were attached, the number was recorded for each tree, and with it the tree species, d.b.h., crown class, and general vigor as near as this could be estimated. Where water occurred, the depth at the base of each tagged tree was recorded. At each succeeding inspection, the condition of the tree and the water depth, which varied as shown in fig. 5, were the main records taken. Trees obviously dying, but still with green leaves or cambium, were so recorded. Observations were made in June and October, 1940; one record was taken in June, 1941, one in October, 1942, and another in October, 1944, table 2. The final record was taken in October, 1946. A total of six inspections, in addition to those at the time of tagging and on numerous visits at other seasons, supplied data for this report.

Supplementing the detailed investigation in the Pere Marquette area were observations made in flooded areas along the



PERE MARQUETTE WILDLIFE EXPERIMENTAL AREA
GRAFTON, ILLINOIS

Fig. 2.—Land and water areas on the Pere Marquette Wildlife Experimental Area, Calhoun Point. Orientation of the six transects supplying sample data is shown by straight, heavy lines. The direction of flow of the Illinois and Mississippi rivers in this area is approximately north-east.

Mississippi River in Jo Daviess, Henderson, and Pike counties, and along the Illinois River in Mason and Jersey counties, all in Illinois. These areas were similar to Calhoun Point except that they were narrower, were bordered by large rivers along only one side, and supported greater proportions of willows and cottonwoods in the stands. The supplementary observa-

tions, confirmatory in nature, are not incorporated in this report.

Common and scientific nomenclature in this paper is, in most instances, based on the following authorities: Kelsey & Dayton (1942) for plants; Necker & Hatfield (1941) for mammals; American Ornithologists' Union (1931) for birds. Some forms were not identified to species.

TIMBER TYPES

Most of Calhoun Point, at the time of permanent flooding, was covered by river-bottom forest characteristic of that found in the upper Mississippi River valley. The stands, varying from sapling to mature growth, contained scores of very large, decadent, and often dying silver maples, with an occasional elm, sycamore, and pin oak of similar type, fig. 3. Com-

position, size classes, and the scientific names of all important trees and shrubs contained in the samples are indicated in table 1.

Silver or soft maple was the most abundant of the large trees in the flooded area. On the lowest level on which trees grew, it easily dominated all plants except semiaquatic species, such as black willow, buttonbush, waterprivet, and waterlocust, fig. 4. Many of the maple

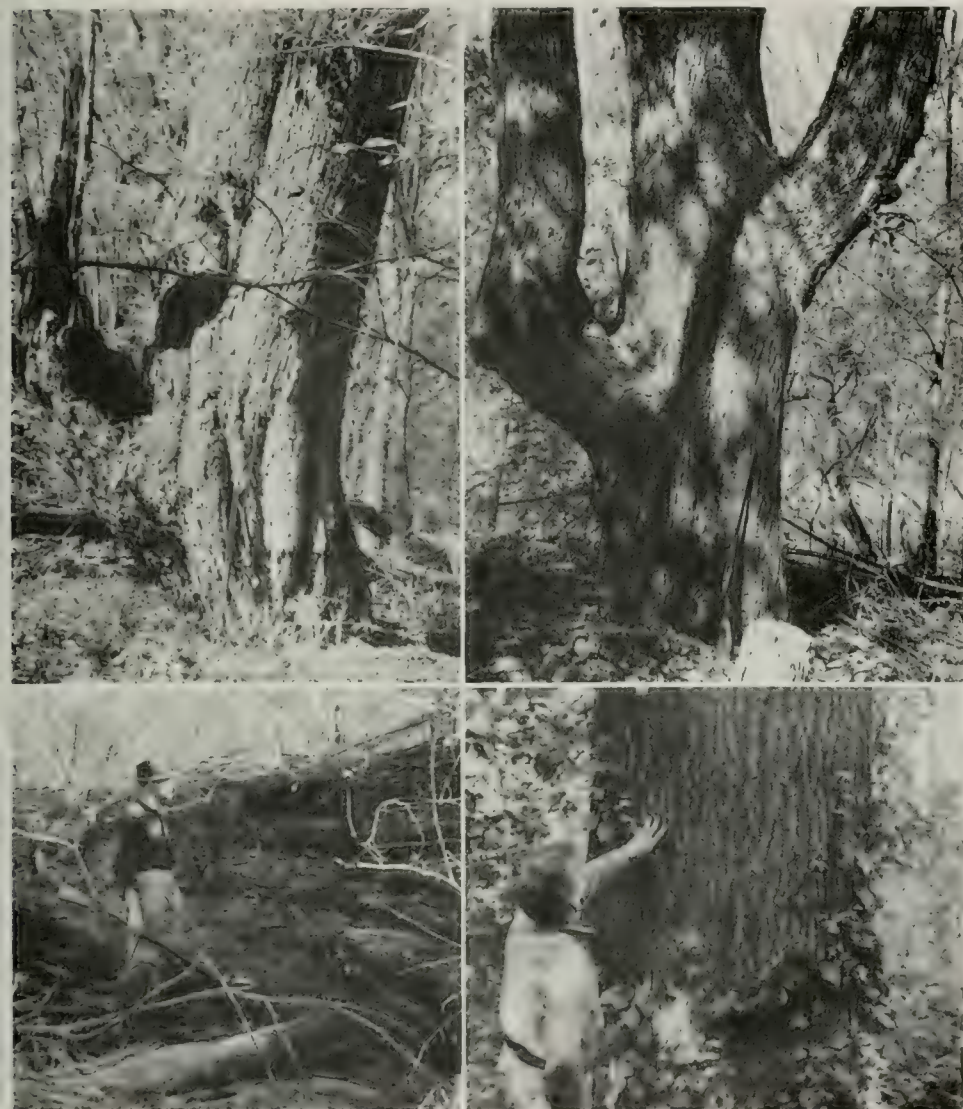


Fig. 3.—Huge, overmature, and characteristically multibranching maples, elms, oaks, and sycamores were found in the Calhoun Point stands, October, 1940.

flats held standing water during the rainy seasons. Maple was also a dominant species on some higher sites, including unflooded ridges. American elm, pecan, and sugar hackberry reached their best development at slightly higher elevations. Ash

The Pere Marquette area is north of the range of baldcypress and water tupelo (*Taxodium distichum* and *Nyssa aquatica*) and evidently of certain other southern river-bottom species, such as blackgum (*Nyssa sylvatica*), American sweetgum



Fig. 4.—Typical stand of silver maple on a "flat" site, October, 1940. Dead and dying trees in background.

was often found on lower sites occupied principally by maple, but occurred at all elevations. Species of secondary importance on elm-ash-pecan sites included persimmon, river birch, hawthorn, and holly.

On the highest land flooded, originally the lower ridges, pin oak, persimmon, cottonwood, and several less important species were found. Waterlocust grew mainly on shore lines but sometimes on ridge sites; waterprivet and buttonbush were confined to shore lines and shallow sloughs, both species often occurring in a foot or more of water. Found on unflooded land, particularly on the higher ridges, were boxelder, red mulberry, red-bud, dogwood, American plum, honey locust, and Kentucky coffeetree, none of which appeared on the flooded portion of the samples, table 1.

(*Liquidambar styraciflua*), and the magnolias (*Magnolia* spp.), which were not represented. The area lies considerably south of the midwestern occurrence of tamarack (*Larix laricina*), spruce (*Picea* spp.), balsam fir (*Abies balsamea*), and northern white-cedar (*Thuja occidentalis*). Black ash (*Fraxinus nigra*), which occurs in Illinois, was not found in the area.

WATER LEVELS

That the water stage at Calhoun Point, even after closing of the Alton Dam, fluctuated considerably is shown in fig. 5. Fluctuation was due in part to winter drawdowns in 1938-39 and 1939-40, to unusually high floods during the springs of 1943 and 1944, and to a less severe flood in the spring of 1945. Several minor

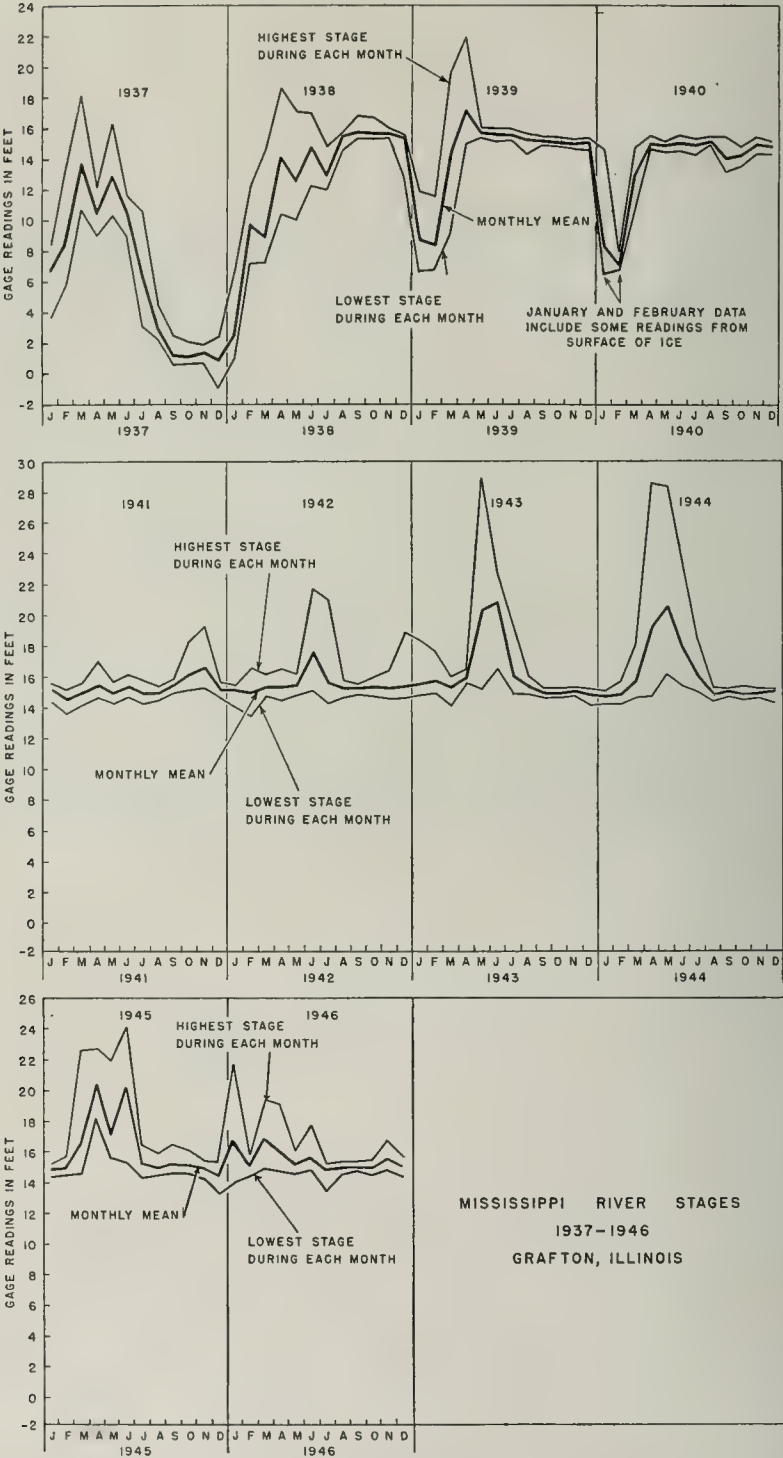


Fig. 5.—Mississippi River stages about 2 miles downstream from Calhoun County study area

fluctuations in water level came at other times. With the exception of the three spring floods, the more pronounced changes came during the dormant season and presumably had only a minor effect on woody species. The peaks of the 1943 and 1944 floods occurred during cool weather before the growing season was fully under way, at least for trees.

TREE MORTALITY

Although it is universally known that most trees and shrubs die when subjected to permanent flooding, the rate of dying, by species, diameter classes, and depths flooded, has received little specific study, and is not well known. Green (1947) reported on the only other study on this subject known to the writer. His work, also in the upper Mississippi River valley, covered the period 1939-1944.

Table 2 indicates roughly the rate of dying in common upper Mississippi River valley trees and shrubs in the Calhoun County study area, and tables 3 and 4

show the effect of flooding on these species by diameter classes and water depths, respectively. Trees indicated in the "land" classification were on unflooded area at pool stage; trees in the "mud" classification were well above the original permanent water level but, subsequent to flooding, mainly along the new shore lines and other low areas of muddy nature; trees in the "water" classification were entirely on newly flooded land, except for willow and buttonbush. These two species, therefore, did not occur in the "land" sample, nor did boxelder, red mulberry, and several less important species in the "water" sample. The effect of flooding on trees under "water," "mud," and "land" conditions is discussed below.

Trees Standing in Water

Virtually all trees permanently flooded to a depth of 20 or more inches were dead by 1946, 8 years after the initial impoundment, fig. 6. Species varied considerably in rate of mortality, table 2. Only



Fig. 6.—Most trees and shrubs flooded to depths above the root collar died in 1 to 6 years. Shown above is a waterprivet, relatively resistant to flooding, that died during the fourth year when flooded 20 inches. The large tree is a persimmon, which died during the second year. A heavy mat of duckweed covered the water in this area. The writer, taking notes, October, 1941.

Table 2.—Rate of dying of trees in six study transects, Calhoun County, Illinois, 1938-1944. Permanent flooding of area was begun in June, 1938.

SPECIES	TREES ON LAND					TREES IN MUD					TREES IN WATER				
	Per Cent of Trees Dead					Per Cent of Trees Dead					Per Cent of Trees Dead				
	Number of Trees Tagged, October, 1939	June, 1940	October, 1940	June, 1941	October, 1942	October, 1944	Number of Trees Tagged, October, 1939	June, 1940	October, 1940	June, 1941	October, 1942	October, 1940	June, 1941	October, 1942	October, 1944
Maple, silver...	219	1.4	2.8	3.2	4.2	5.1	55	0.0	11.1	18.2	20.0	45.5	43.5	54.8	68.4
Elm, American...	98	1.0	2.0	4.1	5.1	6.1	37	0.0	0.0	2.7	13.5	51.4	22.1	34.6	49.0
Ash, white...	59	0.0	0.0	0.0	0.0	0.0	18	0.0	0.0	0.0	0.0	16.7	3.2	3.2	3.2
Oak, pin...	46	4.3	6.5	8.7	19.6	28.2	5	0.0	0.0	0.0	0.0	100.0	71.4	100.0	100.0
Pecan...	46	0.0	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0	100.0	23.0	42.4	61.5
Waterprivet...	18	0.0	0.0	0.0	0.0	0.0	5	0.0	0.0	0.0	0.0	0.0	32.0	42.6	53.2
Persimmon...	27	3.7	3.7	3.7	3.7	3.7	5	0.0	0.0	0.0	0.0	80.0	22.9	42.9	48.6
Waterlocust...	24	0.0	0.0	4.2	4.2	4.2	2	0.0	0.0	0.0	0.0	100.0	36.0	52.0	64.0
Hackberry...	45	0.0	2.2	2.2	4.2	4.2	3	0.0	0.0	33.3	33.3	66.7	3	33.3	33.3
Hawthorn...	17	11.7	11.7	11.7	11.7	11.7	4	0.0	0.0	0.0	75.0	75.0	16	56.2	81.3
Willow, black...	0						0	0.0	0.0	0.0	0.0	0.0	23	13.0	17.4
Birch, river...	4	0.0	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0	0.0	17	76.5	94.0
Boxelder...	20	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
Mulberry, red...	15	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
Buttonbush...	0						0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
Cottonwood...	5	0.0	0.0	0.0	0.0	0.0	1	0.0	0.0	0.0	0.0	0.0	20.0	26.6	40.0
Holly...	6	0.0	0.0	0.0	0.0	0.0	1	0.0	0.0	0.0	0.0	0.0	11.1	44.5	66.7
Oak, bur...	3	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	8	25.0	37.5
Sycamore...	6	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	5	20.0	100.0
Dogwood...	2	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
Plum, American...	1	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
Elm, slippery...	1	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
Coffeetree...	1	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
Redbud...	1	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
Total	661	1.4	2.3	3.0	4.2	5.3	140	0.0	4.3	8.6	17.9	45.7	33.7	47.1	58.0
															93.5

* Sample indicated that 93 per cent were dead in 1946.

† Sample indicated that about 85 per cent were dead in 1946.

‡ Sample indicated that 61 per cent were dead in 1946.

** No sample taken in 1946.



Fig. 7.—Diameter of tree or shrub had little effect on survival after flooding except in semi-aquatic species and in reproduction sizes. In the area pictured above, all trees of 3 to 30 inches (larger trees in background) had succumbed by October, 1946, in 8 years of permanent flooding.

buttonbush, willow, and, to a less degree, waterprivet appeared to be adapted to conditions induced by impounded waters. Buttonbush did not succumb except where completely, or nearly, inundated. The few ash trees still living in October, 1946, were obviously dying.

Trees and shrubs of the various diameter classes showed little differentiation in survival ability after flooding except in the 2-inch class, table 3. In this class the difference was due to species (waterprivet and buttonbush, both semiaquatic) rather than to size, fig. 7. In general, healthy, vigorous trees of each species showed the greatest resistance to flooding, and the very small and the overmature classes of each species showed the least resistance.

Trees and shrubs still living and vigorous in 1944 were, in all cases, on the less deeply flooded areas; only waterprivet,

buttonbush, and black-willow shrubs or trees still survived in water over 20 inches deep, table 4. More than half of the waterprivets and willows were dead by October, 1946. Before 1938, willows grew naturally in water or on the banks of sloughs and were flooded to greater depths than any other tree species; the depth averaged approximately 3 feet on the lower (northern) end of Calhoun Point. Had willows occurred in position to sustain all depths of inundation, a higher percentage of survival probably would have resulted. To all but semiaquatic species, permanent flooding to a depth of 20 inches or less above the root collar was fatal.

Trees Standing in Mud

Trees in mud, in comparison with trees standing in water, showed a more or less

Table 4.—Mortality of trees, by depth flooded, resulting from permanent flooding of river-bottom timber in six study transects, Calhoun County, Illinois, 1938-1944.*

SPECIES	WATER DEPTH, INCHES												Total					
	1-10			11-20			21-30			31-40				41 and over				
	Number of Trees	Dead	Per Cent Dead	Number of Trees	Dead	Per Cent Dead	Number of Trees	Dead	Per Cent Dead	Number of Trees	Dead	Per Cent Dead		Number of Trees	Dead	Per Cent Dead		
Maple, silver	57	57	100.0	71	71	100.0	33	33	100.0	12	12	100.0	4	4	100.0	177	177	100.0
Elm, American	56	56	100.0	40	40	100.0	6	6	100.0	2	2	100.0	0	0	—	104	104	100.0
Ash, white	17	9	55.5	7	6	85.7	2	2	100.0	3	3	100.0	2	2	100.0	31	22	71.0
Oak, pin	15	15	100.0	7	7	100.0	6	6	100.0	0	0	—	0	0	—	28	28	100.0
Pecan	7	7	100.0	16	16	100.0	3	3	100.0	0	0	—	0	0	—	26	26	100.0
Waterprivet	6	2	33.3	12	10	83.3	7	6	85.7	11	10	90.9	11	11	100.0	47	39	83.0
Persimmon	13	13	100.0	16	16	100.0	2	2	100.0	4	4	100.0	0	0	—	35	35	100.0
Waterlocust	4	3	75.0	10	10	100.0	6	6	100.0	1	1	100.0	4	4	100.0	25	24	96.0
Hackberry	2	2	100.0	1	1	100.0	0	0	—	0	0	—	0	0	—	3	3	100.0
Hawthorn	5	5	100.0	6	6	100.0	3	3	100.0	2	2	100.0	0	0	—	16	16	100.0
Willow, black	5	0	0.0	7	1	14.3	2	1	50.0	3	2	66.7	6	6	100.0	23	10	43.5
Birch, river	5	5	100.0	6	6	100.0	4	4	100.0	0	0	—	2	2	100.0	17	17	100.0
Burtonbush	3	0	0.0	3	1	33.3	2	1	50.0	1	1	100.0	6	6	100.0	15	9	60.0
Cottonwood	4	4	100.0	4	4	100.0	1	1	100.0	0	0	—	0	0	—	9	9	100.0
Holly	6	6	100.0	2	2	100.0	0	0	—	0	0	—	0	0	—	8	8	100.0
Oak, bur	0	—	—	2	2	100.0	1	1	100.0	2	2	100.0	0	0	—	5	5	100.0
Total	205	185	90.2	210	199	94.8	78	75	96.2	41	39	95.1	35	35	100.0	569	532	93.5

* See footnotes for table 2 regarding white ash, waterprivet, black willow, and buttonbush.

parallel, but less severe, mortality rate, table 2. In the transects selected for study, the number of trees in mud was small; also, the ultimate effect of mud, after 8 years, was less obvious than that of water, since reactions in this medium were slower.

In view of the small area of mud in the transects, supplementary observations were made in October, 1944. The data obtained vary from those of the transect samples only in method and places of collection. As presented in table 5, the supplementary data represent a special effort to enlarge the mud sample, particularly for cottonwood, birch, hackberry, persimmon, pecan, buttonbush, and pin oak. They were collected from strips running parallel to mud flats rather than at right angles to them. These parallel strips were near transects 1, 6, and 7, and were 30 to 50 feet wide; trees were taken in order of occurrence, regardless of species, size, or condition. It is believed that this procedure eliminated the error of selectivity, and, since the two sets of data show similar trends, together they give added reliability to the conclusions.

Raising of the water table so as to turn low ridges into mud flats resulted in timber mortality at the end of 6 years that ranged from 50 per cent to nearly 100 per cent, except for such species as privet, white ash, river birch, and cottonwood. The species best able to tolerate change of

this kind clearly are waterprivet and buttonbush, as would be expected. By 1946, it appeared likely that a higher percentage of trees of all species would die in time, and that the mud flats would support cattail (*Typha latifolia*) or other marsh plants, or grow up to willow, cottonwood, white ash, and perhaps other forest reproduction, fig. 20. Extensive invasion of cattail, and, in some cases, arrowhead or duckpotato (*Sagittaria* spp.), fig. 8, had occurred prior to the extreme floods of April and May, 1943 and 1944, which destroyed most of them. In 1946, these marsh plants were reappearing.

In a study of the influence of flooding in upper Mississippi River pools, Green (1947) noted few deleterious effects on timber growing on land higher than the contour 2 feet above normal pool level. In the present study, the "mud" sample lay lower than the 2-foot contour, being in fact where the water table lay at or very near the ground surface. Green noted the appearance of forest reproduction on cleared area between pool stage and the 2-foot contour. Similar observations were recorded many times during the present investigation.

Trees Standing on Land

Even for land not actually flooded the water table was raised approximately 3 feet as a result of closing the Alton Dam.

Table 5.—Mortality in various species of trees on mud sites in study area, Calhoun County, Illinois, October, 1944. Permanent flooding of area was begun in June, 1938.

SPECIES	SAMPLE (FROM TABLE 2)		SUPPLEMENTARY OBSERVATIONS	
	Number of Trees	Per Cent Dead	Number of Trees	Per Cent Dead
Maple, silver.....	55	45.5	48	45.8
Elm, American.....	37	51.4	62	54.8
Ash, white.....	18	16.7	30	16.7
Oak, pin.....	5	100.0	25	96.0
Pecan.....	2	100.0	20	85.0
Waterprivet.....	5	0.0	17	0.0
Persimmon.....	5	80.0	23	78.3
Waterlocust.....	2	100.0	0	—
Hackberry.....	3	66.7	11	81.8
Hawthorn.....	4	75.0	6	83.3
Birch, river.....	2	0.0	10	20.0
Buttonbush.....	0	—	18	0.0
Cottonwood.....	1	0.0	18	27.8
Holly.....	1	0.0	0	—
Total.....	140	45.7	288	49.3



Fig. 8.—Cattail, rice cutgrass, duckpotato, smartweed, and other marsh or moist-soil plants invading timberland where the water table had been raised to the soil surface. Timber stand is dead or dying, October, 1941.

That timber stands were affected thereby was apparent, though not conspicuously so except in pin oak. This species, even on the unflooded land, suffered a mortality of 28.2 per cent by October, 1944, little more than 6 years after initial impoundment, and dying was noticeably progressive. Mortality in other common species was much lower, table 2. White ash, pecan, cottonwood, waterprivet, and several other species on unflooded land showed no loss as a result of the rise in the water table. Willow and buttonbush were not represented in the land sample.

By October, 1944, the two most numerous species on the area, silver maple and American elm, showed losses of 5.1 and 6.1 per cent, respectively, probably somewhat greater than natural mortality in stands where large poles and standards predominate. On land, the greatest loss in both maple and elm, as well as other species, was in the very large, overmature trees. The other common river-bottom species, persimmon, hackberry, and water-locust, showed only slightly lower death rates than maple and elm. The death of

two very large, old hawthorns, among 17 trees of this genus growing on land in the transects, is believed to have resulted from natural causes, rather than flooding, as other hawthorns growing outside of the transects were observed to be tolerant of the raised water table.

Discussion

Pin oak was easily the species most susceptible to injury by flooding, showing symptoms of dying as well as complete mortality before any other. Pin oak trees flooded in June, 1938, were clearly in a dying condition in September, 1939; by June, 1940, over 70 per cent had died, table 2. All were dead by October, 1940. In water, river birch indicated a slightly higher mortality rate than pin oak by June, 1940, but a somewhat slower dying rate thereafter. Pin oak trees in mud and on land sites with raised water levels died less rapidly than those in water, but all in mud succumbed before October, 1942, little more than 4 years after the original impoundment. A water table

raised to the ground level (trees in mud) was less injurious to river birch than to pin oak. Of the trees in water, hawthorn and silver maple, in June, 1940, were third

and fourth, respectively, in rate of dying. The approximate number of years at which various species reached 100 per cent mortality is shown in table 6.



Fig. 9.—White ash was among the tree species most resistant to flooding. A few vigorous individuals, in less than 2 feet of water, threw trunk sprouts in 1946, during the ninth year of flooding. Two recently built duck blinds are shown in the center background.

Some pin oak trees died in 1 year, and other species showed high loss at least 1 year before the time of 100 per cent mortality. Most maples (98.9 per cent) and elms (97.1 per cent) were dead in little more than 4 years, table 2. Surviving white ash and waterlocust trees at the end of 6 years were so severely injured that few showed leaf in 1946. However, a few white ash trees showed small green trunk sprouts in October of that year.

Table 6.—Approximate period of flooding, up to 3 feet, required to kill all trees of various species in six study transects, Calhoun County, Illinois.

TWO YEARS, OCTOBER, 1940	THREE YEARS, OCTOBER, 1941	FOUR YEARS, OCTOBER, 1942	FIVE YEARS, OCTOBER, 1943	SIX YEARS, OCTOBER, 1944	SEVEN YEARS, OCTOBER, 1945	EIGHT YEARS, OCTOBER, 1946
Pin oak	Bur oak Hackberry*	Hawthorn Cottonwood	Silver maple† American elm†		Waterlocust‡	White ash** Buttonbush
	Persimmon*	Holly		Pecan		Water- privet†† Black willow††
	River birch*					

* Listed as probable; all trees nearly dead at time of June, 1941, inspection; no check made in October, 1941.
† Listed as probable; no check made in October, 1943.
‡ Listed as probable; no check made in October, 1945.
** All trees virtually dead after 8 years; a few trees with small green sprouts on trunks in October, 1946.
†† Uncertain; some trees at edge of flooded area in shallow water still living.

These were young trees flooded to a depth of less than 2 feet, fig. 9. Waterprivet, buttonbush, and willow, all semiaquatic, survived in varying percentages. Invariably, living trees and shrubs in each species were those subjected to the shallowest flooding depths, in all except semiaquatic species less than 2 feet.

In summary, it may be said that flooding, under the conditions described, resulted in the death of most trees within a 5- or 6-year period. Although the effect of the three flooding conditions listed in table 2 differed only in degree in most species, several species, notably white ash, river birch, and cottonwood, were not greatly affected by a raised water table or flood-induced mud. These three species appear to be more tolerant of increased soil moisture than pin oak, American elm, pecan, persimmon, and others.

It was noted with interest that several species bore fruit under flooded conditions. During the second year after flooding, individual trees or shrubs of persimmon, hawthorn, holly, locust, cottonwood, wil-

low, hackberry, privet, and buttonbush bore appreciable crops; and trees of maple, elm, ash, river birch, and pecan produced small crops. During the third year, willow, waterlocust, and waterprivet produced sparse crops and buttonbush a normal crop. Several persimmon trees growing on a steep-banked slough (Chickahominy, fig. 2) and with root systems inundated only on the lower or stream side, produced well in 1944. These trees died

subsequently. Some pin oaks matured acorns in 1938, after being flooded temporarily in June of that year. No acorns were noted on flooded pin oaks in 1939, but they were observed that year on flooded bur oaks. Pin oaks on the highest land sites bore good crops in 1940, 1942, and 1944, but light to medium crops in the intervening years.

Differential rates of dying in parts of the same tree were commonly noted. This condition occurred where trees grew on the shores of steep-banked sloughs, in such position that the root collars were flooded on the stream side, but lay above the post-flooding level on the land side. Pecan, fig. 10, showed this differential dying phenomenon most frequently, but the same condition was noticed also in elm, cottonwood, and maple. A score or more of partly dead trees were observed on the banks of Big Slough in October, 1946; it seemed probable that most of these would die in time.

The setting of adventitious roots, particularly in willow, white ash, and buttonbush, and to a lesser degree in silver



Fig. 10.—Some pecans and other trees with root collar flooded on one side but above water level on the other side died first on the flooded side.

maple, was especially noticeable in 1939 and 1940. Such root growth was most pronounced near the new water line, but, in decreasing density, it extended down the trunk and thus for several inches below the water surface. This reaction of certain woody species to the stimulus of a raised water level is, of course, well known.

The effect of flooding on forest reproduction was similar to that in parent trees. An 8-acre clearing south of Sawmill Slough showed in 1938 a dense stand of

seedlings, with some stump sprouts of elm, maple, and other species. In October, 1939, practically all of this reproduction except that of white ash and waterlocust showed evidence of dying; in October, 1940, all was dead except white ash in a foot or less of water. Even the 4- to 6-foot ash seedlings succumbed where flooding occurred to a depth exceeding 12 or 15 inches. Of all species represented, ash reproduction showed greatest tolerance to permanent flooding.

TREE FALL

Tree fall in the following discussion refers to the dropping of branches as well as to actual fall of the tree, wholly or in part, in flood-killed timber as a result of death, decay, and wind action.

Rate and Manner of Falling

Falling of water-killed trees was not particularly noticeable until 1941, 3 years after the initial flooding. Prior to this time scattered trees and large branches had crashed, but this early fall was principally among the numerous large, multi-branched and decadent silver maples and small, badly suppressed trees of all species. Many of the large maples were 4 feet or more in diameter and some of them probably would have fallen if flooding had not occurred, fig. 3. By October, 1944, falling was more or less advanced in all species, indicating, as would be expected,

rapid decay in this low, humid locality, figs. 11 and 12. Falling data are summarized in table 7.

The manner of falling in dead trees was confined to two general patterns, determined by the presence or absence of durable heartwood. Among the species having durable heartwood, pin oak was outstanding. Although the first to succumb to flooding, pin oak was the last to fall after death. Bur oak showed rather similar characteristics. Oak branches, particularly the larger ones, were slow to fall, since they contained a considerable volume of heartwood. In oaks, the sapwood decayed and fell usually off both trunk and larger branches, leaving standing skeletons of heartwood. Five years or more were required for this degree of decay. Dead oaks with sound wood were usually uprooted by winds rather than broken off, although in oaks weakened by advanced heart rot the reverse was true. Waterlocust, except for the larger trees, many of which were decadent, possessed strong heartwood and stood well. Branches of locust trees tended to fall after a year or two. White ash, with only fairly durable heartwood, and often with advanced heart rot in the larger trees, was intermediate in ability to stand.

There is a long list of river-bottom trees known to have quick-rotting heartwood. Most numerous of these trees on the study area were silver maple, American elm, pecan, persimmon, sugar hackberry, cottonwood, river birch, and willow. Of these species persimmon and over-mature maple trees fell first. Multi-branched, spreading trees of all species characteristically lost their branches, leaving low, stubby, and often hollow snags. Vigorous maple, hackberry, birch, and willow trees were somewhat slower in falling, and all fell at about the same rate. Among species having nondurable heartwood, elm, pecan, and cottonwood were most resistant to falling. Cottonwood was surprisingly durable; mature trees dying in 1942 and possibly earlier were cut for lumber in the fall of 1944. Such trees, while having decayed sapwood, usually showed sound, though often stained, heartwood; they had been vigorous in life; and many of them were 2 and some 3 or more feet in diameter, fig. 13.

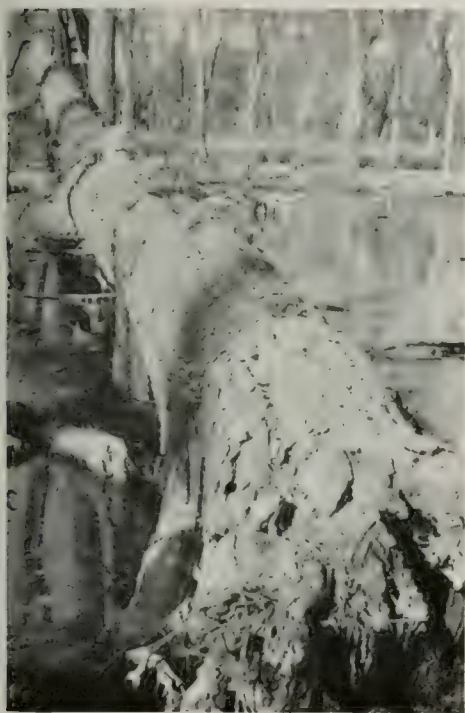


Fig. 11.—Silver maple wind-thrown in 1940, about 2 years after initial inundation of the Calhoun County study area. Photographed in October, 1940.

Table 7.—Degree of falling in river-bottom timber on six study transects, October, 1944 and 1946, Calhoun County, Illinois.* Permanent flooding of area was begun in June, 1938.

SPECIES	NUMBER OF TREES DEAD	DEGREE OF FALLING†											
		Main Branches On		Main Branches Off		One- Fourth Down		One- Half Down		Three- Fourths Down		Down	
		1944	1946	1944	1946	1944	1946	1944	1946	1944	1946	1944	1946
Maple, silver...	232	64	4	23	22	30	45	52	68	24	38	39	55
Elm, American...	141	74	9	29	18	10	38	18	32	2	14	8	30
Ash, white...	49	37	8	0	12	0	8	4	5	0	4	8	12
Oak, pin...	33	14	9	8	10	3	5	4	4	2	3	2	2
Pecan...	28	3	0	11	8	6	10	5	6	2	2	1	2
Waterprivet...	52	20	0	0	4	3	8	12	13	1	8	16	19
Persimmon...	40	3	0	3	0	2	3	7	8	7	9	18	20
Waterlocust...	27	6	1	10	9	2	8	4	4	1	1	4	4
Hackberry...	6	2	0	2	0	1	4	0	1	0	0	1	1
Hawthorn...	20	8	0	2	0	1	5	5	7	0	2	4	6
Willow, black...	23	0	0	0	0	0	0	7	4	2	1	14	18
Birch, river...	19	0	0	0	0	1	2	12	12	2	0	4	5
Buttonbush...	15	3	0	0	0	0	0	3	0	0	5?	9	10?
Cottonwood...	10	1	0	3	0	3	2	0	3	1	1	2	4
Holly...	9	4	0	0	0	0	2	0	0	0	0	5	7
Oak, bur...	5	0	0	0	0	1	0	3	2	1	2	0	1
Total.....	709	225	31	105	83	63	140	136	169	45	90	135	196

* Water and mud sites combined, tagged sample only. See text for discussion of 1946 data.

† "One-Fourth," "One-Half," etc., refer in each case to that portion of trunk broken off.

It was characteristic of species having nondurable wood to break off at varying distances above the ground; in such species, standing heartwood skeletons did not long remain, as they did in the oaks. Persimmons particularly showed a tendency to snap cleanly, leaving stubs ranging from 1 to 20 feet high. Maples that had been sound and vigorous, and all other central-stemmed species in the nondurable group, first lost their branches and soon afterward broke off at some point one-fourth to one-half way down from the top of the main stem, fig. 14. Decadent trees in this group tended to break off at some point of weakness, such as a rotted branch stub.

Although falling was not common until 1941, 3 years after permanent flooding was begun, it was so advanced in October, 1944, that travel in many places was not possible in a light canoe. A number of channels cleared prior to flooding were blocked in scores of places by logs and debris. Many areas that were maple flats and shallow sloughs at the time of flooding had become, at the end of 6 years, so many acres of stubs, varied in height and standing in shallow water that was clogged by

a maze of fallen tree tops and trunks, fig. 15.

By October, 1946, approximately 8 years after permanent flooding was begun, tree fall had obliterated transect markings to such an extent that these lines could be followed only with difficulty where they crossed flooded areas. It was often impossible to find the metal tags with which sample trees had been marked. Some of these tags were undoubtedly buried on the undersides of fallen trees, in a foot or more of mud; others, presumably, had dropped off the rapidly decaying trunks and were lost in the mud and water below. For this reason, the entries under 1946 in table 7 do not have as high a degree of accuracy as the data for other years. The writer is confident, however, that the trend indicated by the 1946 data is not misleading, since falling was obviously far more advanced in October, 1946, than at the time of the 1944 inspection.

Fate of Fallen Trees

Most of the falls on Calhoun Point were in water. Many tops and branches

landed on end, becoming deeply embedded in the soft mud bottom. Many tree trunks, even when they fell in water deep enough to float them, became waterlogged and sank. Trees falling in shallow water,

cottonwood and willow, are constant sources of river driftwood. Clearing of the shore lines appears to be the most practical method of reducing the amount of driftwood which, in navigable streams, is



Fig. 12.—Same log as in fig. 11, October, 1946. Dying in 1939 and falling in 1940, this maple showed advanced decay and disintegration, to be expected of nondurable woods in low, humid localities in the temperate zone.

unless held up by other falls, settled in the mud. Thus, logs and tops tended to remain on or very near the site of fall, or, if dislodged, were soon caught against the thousands of trees and stubs that covered the area. Comparatively few of these logs reached the Illinois and Mississippi rivers from the interior of the Pere Marquette tract, even during the severe floods of 1943 and 1944.

Many green or flood-killed trees that have grown along the shores of navigable streams are uprooted and swept into the main channels. Flooded, uncleared islands in the Mississippi River, covered mostly by

an appreciable nuisance or even a hazard to river shipping and also to commercial fishing.

That few logs from Calhoun Point reached the Mississippi River was due to the fact that, prior to flooding, an extensive and thorough clearing operation had been performed along the Illinois River shore line. Much of the Mississippi River shore line at this point is low bluff, somewhat higher than pool stage. For this reason little or no tree mortality occurred from the rise in water level, and no dead timber from this shore reached the river channel.

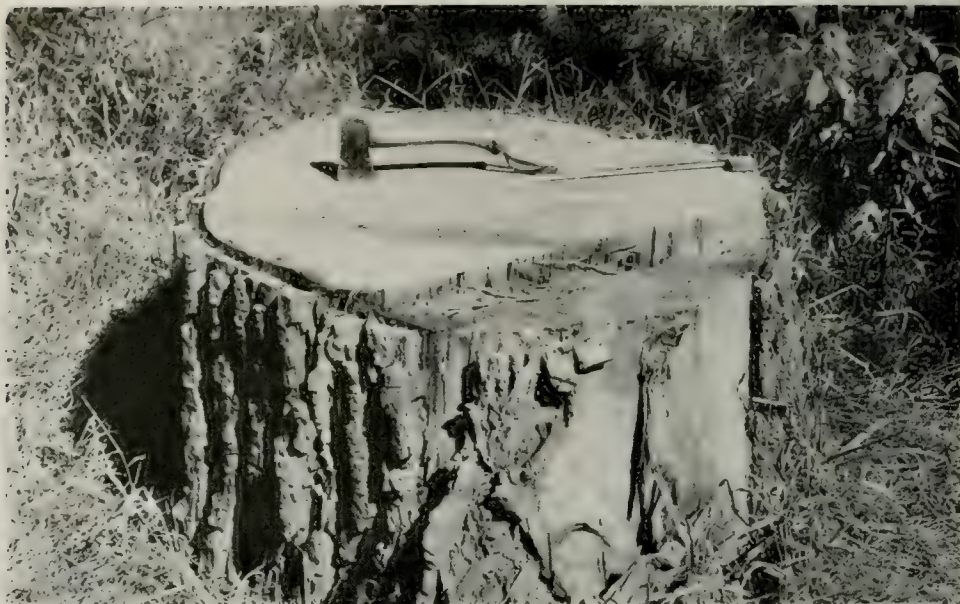


Fig. 13.—A 42-inch cottonwood flooded about 4 inches on the lower side in 1938. It died in 1942 and was cut for lumber in 1944. The heartwood was still sound but stained in October, 1946.

POST-FLOODING SUCCESSION

General, and for the most part incidental, observations on changes in plant and animal life subsequent to flooding were recorded during the investigation. Very profound changes are, of course, still in progress; this report is merely a summary of early succession phenomena.

Plants

The most conspicuous change in plant life was that of death in flooded timber. At the end of 8 years, most of the dead and fallen stand was in water less than 3 feet deep.

Conversion of much of this area, log-filled and snag-studded, to marsh was to be expected, and this transition had begun before 1946. Ecological development in the area following flooding may be ascribed largely to spread of plants already present and to introduction of seeds by water. As early as 1938, 2 years after excavation, borrow pits on the east end of the area supported vigorous stands of cattail (*Typha latifolia*). By 1940, cattail

stands had appeared in a scattered pattern on most of the water areas, as well as on wooded sites (timber dead) where the water table approached the ground surface, fig. 8. Stands of duckpotato (*Sagittaria* spp.) were particularly abundant along the lower end of Big Slough, where the channel had been deepened. Along the shore lines of both the Illinois and Mississippi rivers, rows of smartweed (*Polygonum* spp.) and cockspur or wild millet (*Echinochloa* spp.) appeared in both mixed and pure stands, undoubtedly due to the windrowing effect of wave action, fig. 16. Luxuriant growths of rice cutgrass (*Leersia oryzoides*) developed along the margins of many flooded areas in 1946, fig. 17.

Water in the sloughs and lakes, backwater in nature and without current except that induced by the rise and fall in pool levels, became progressively clearer toward the head of such bodies, even with the initial inundation in 1938. This condition permitted luxuriant growths of coontail or hornwort (*Ceratophyllum demersum*) and leafy pondweed (*Potamogeton foliosus*), which became very noticeable in 1939 and reached their greatest development in

1942. Very heavy stands of sedges (*Carex* spp.) sprang up along some of the more open sloughs and shallow-water areas. The water supported a layer of duckweed (*Lemna*, *Wolffia*, and *Spirodela*), commonly 1 inch thick, figs. 6 and 18. Filamentous algae covered every submerged object, fig. 19.

Extreme flood conditions during the early growing seasons of 1943, 1944, and 1945 had a profound effect on submerged and most emergent vegetation. The smothering effect of muddy, silt-laden flood water severely decreased the stands; during the summer and fall of 1943 and 1944, only scattered growths appeared; by 1945, all the plants mentioned above except duckpotato virtually disappeared from the area, but many of them had reap-

peared by the fall of the following year. Moist-soil species, particularly rice cut-grass, appeared in dense stands in 1946, probably from seed deposited by flood waters.

Forest reproduction, principally willow and cottonwood, appeared along the shore lines of the Mississippi and Illinois rivers as early as 1939, particularly where clearing had been done. Growth was vigorous in 1940. These species also appeared along the shore lines of the shallower and more open sloughs. Seeding was of course by wind and water from numerous parent trees still present on surrounding unflooded land.

On certain wet "flats," notably northwest of Lower Royal Lake and along part of the Illinois River shore line, silver



Fig. 14.—A silver maple stand, October, 1946, 8 years after inundation, showing falling and break-off characteristic of species having nondurable heartwood.



Fig. 15.—Silver maple "flat," flooded in 1938; a maze of fallen debris in October, 1946.



Fig. 16.—Stand of smartweed (*Polygonum* spp., chiefly *lapathifolium*) along the Illinois River on Calhoun Point, October, 1941. Seed presumably "windrowed" by wave action.

maple reproduction was abundant in October, 1944, reaching a density of four stems per square foot on small areas. White ash and American elm seedlings were common. Some pecan and pin oak reproduction was noted at various points. By October, 1946, practically all open, unflooded land supported a fair to full stand of river-bottom forest seedlings. Maple, elm, ash, willow, cottonwood, pin oak, and pecan reproduction was growing vigor-

ously at this time; in some places it was as much as 10 or more feet high, fig. 20.

Mammals

Among mammals, muskrats (*Ondatra zibethicus zibethicus*) were most receptive to conditions brought about by permanent flooding of about one-fourth of Calhoun Point. In a complete coverage of the area in February, 1938, Frank C.



Fig. 17.—Rice cutgrass had attained luxuriant stands along the margins of flooded woodland in the study area by October, 1946.



Fig. 18.—Mat of duckweed an inch thick covered much of Royal Lake, Calhoun Point, October, 1941.



Fig. 19.—Filamentous algae grew in heavy mats over every submerged object, here revealed by a 16-inch drawdown, October, 1940.



Fig. 20.—Willow, cottonwood, elm, and silver maple reproduction on mud flat following death of most of the original stand as a result of flooding that raised the permanent water level nearly to the ground surface. A luxuriant stand of rice cutgrass grew between the bare mud flat and the forest zone in October, 1946.

Bellrose, Jr., of the Illinois Natural History Survey (personal communication) found no sign indicating the presence of these animals. In April of that year, temporary closing of the Alton Dam flooded the borrow pits and sloughs along the rivers, and within a few days muskrats appeared. Muskrat signs were fairly common on June 2, 1938, and in places abundant in October of the same year. Strong evidence was found during the next 3 years that muskrats were increasing in numbers. By October, 1940, muskrat cuttings (chiefly of cattails and sedges), droppings, and burrows were noted in or near practically every slough on the area, fig. 21.

The steady increase in numbers of muskrats in the Calhoun Point study area (Yeager & Rennels 1943) is reflected by complete or partial counts of trappers' catches for five seasons, as follows:

TRAPPING SEASON	MUSKRATS TRAPPED
1938-39	50-75
1939-40	225
1940-41	260
1941-42	350*
1942-43	400*

* Number does not represent a complete count.

The severe floods of 1943 and 1944 and a lesser flood of 1945 appeared to reduce the muskrat population appreciably, but muskrat signs were again common over much of the area in October, 1946. The destruction of cattail, coontail, and duckpotato by floods, as discussed under "Plants," probably accounted for seemingly increased use of sedges, smartweed rootstocks, and mussels late in 1944.

The effect of flooding on other fur animals of the study area is given in part by Yeager & Rennels (1943). Heavy trapping and loss of habitat, 1938-1940, resulted in decreased raccoon (*Procyon*

litor) numbers during the next 2 or 3 years. However, this species, on Calhoun Point as elsewhere throughout its range, showed strong recovery by 1943. The raccoon population on the study area was high in 1944.

Opossums (*Didelphis virginiana virginiana*), never heavily trapped or hunted

floods reached their peaks during the young-rearing seasons. It is therefore not improbable that most of the animals, except those near the river bluffs, perished during the inundation. It should be remembered that, however well housed above the water level, any animal without food will find itself in dire straits before



Fig. 21.—Muskrat burrows under an old stump exposed by a drawdown of the water level of the Illinois River at Calhoun Point, October, 1940. The animals had attempted to plug entrances following exposure.

after about 1939 because of low fur prices, remained numerous on Calhoun Point until 1943, when floods of that year and 1944 apparently reduced their numbers to a very low point. Astonishing as it may seem, not a single opossum track was seen during an inspection trip over the area that lasted from October 13 to 18, 1944, although special efforts under excellent conditions were made to find such tracks. No reason other than flooding can be given for the scarcity of opossums. These animals are good climbers but not good swimmers, and they do not possess marked ability to take food from water. Since the entire point was flooded to a depth of several feet in both years, opossums there were separated from land by flood waters for as much as 3 miles. Moreover, the

the end of a 2- or 3-week flood peak. Opossums showed some indication of coming back to Calhoun Point by October, 1946, but at that time they were far below their 1942 numbers.

Minks (*Mustela vison*), animals that are highly adaptable and equally at home on land or in water, were affected by the Calhoun Point floods less than any other fur species. Signs indicating substantial populations were noted during every year of the study.

Both red foxes (*Vulpes fulva*) and gray foxes (*Urocyon cinereoargenteus cinereoargenteus*) were present on Calhoun Point previous to the initial flooding in 1938. Flooding reduced the habitable area for both species, and the peak floods of 1943 and 1944 undoubtedly evicted

them from the area. Abundant signs of foxes were never observed on the study area after 1944, though fox density on adjacent, but higher, areas remained at a very high point for several years.

Striped skunks (*Mephitis mephitis*) were more numerous in 1938 than at any other time of the study. Even in that year dens appeared to be confined to the high ridge—the fallow field and the woods to the north of the field, both east of Big Slough. Flooding and the resultant 3-foot rise in the permanent water level undoubtedly made the area less suitable for this ground-denning species.

Woodchucks (*Marmota monax monax*) also were adversely affected by permanent flooding, although along the higher ridges their dens and other signs were fairly common in October of 2 years of this study, 1944 and 1946.

Calhoun Point has long been a favored locality for squirrel hunters. Until about 1940, gray squirrels (*Sciurus carolinensis*) predominated, as was attested by numerous hunters. Fox squirrels (*Sciurus niger rufiventris*), until that time, were most common along the pin oak ridges bordering the large opening in the center of the area and along Big Slough and the west boundary, both territories adjoined by cultivated fields. With the death of large tracts of flooded timber and the resultant opening up of the stands, fox squirrels became the dominant species over practically the entire area. In October, 1944, the writer covered every part of the 4-square-mile tract and observed a total of 24 fox squir-

rels and 4 gray squirrels. Previously, the two species were more nearly equal in numbers.

Cottontail rabbits (*Sylvilagus floridanus*) were notably scarce on Calhoun Point, even before the 1943 and 1944 floods, which undoubtedly evicted them from the tract. They were more common along the inland boundaries of the area, and on adjacent farm land, a circumstance to be expected in view of the very low, wet nature of the greater part of Calhoun Point. Both food and nesting conditions on the study area were obviously less favorable than where waste grain, clovers, and other farm crops afforded abundant food, and higher sites provided safer nesting grounds.

Birds

Succession in bird life on this tract of flooded bottomland is indicated here only from general observations. Aquatic and marsh species, common before 1938, had become more numerous by 1944. Some indication of the increase is reflected in table 8, the data for which were taken from one 7-mile boat or canoe trip in each of 4 years on Big Slough, Royal Lake, Chickahominy Slough, and the Illinois River. The same route was followed at each observation. The general validity of the data in table 8 is strengthened by a number of other trips over the tract that yielded similar information.

Calhoun Point has been subjected to heavy duck hunting since 1938. One hun-

Table 8.—Numbers of birds observed on a 7-mile water trip through Pere Marquette study area in each of 4 years.

SPECIES	NUMBER OF INDIVIDUALS*			
	August 16, 1938	August 6, 1941	October 15, 1944	October 3, 1946
Wood duck	16	100	116	62
Black-crowned night heron	11	50	42	39
Yellow-crowned night heron	0	2	0	0
Great blue heron	6	10	22	19
American egret	6	68	40	31
Green heron	13	40	24	26
American bittern	1	2	0	3
Red-wing blackbird	10	56	40	24
Woodpeckers†	7	36	52	114

* All figures over 10 ending in "0" are estimates, believed to be conservative.

† Red-headed, pileated, flicker, downy, hairy, and red-bellied.

dred or more blinds scattered through the 4-square-mile area resulted in widespread shooting almost daily during each hunting season. Because waterfowl were thus discouraged during the fall in their attempts to use the new marsh and flooded woodland, evaluation of the area for waterfowl purposes has been complicated. However, the tract became potentially more attractive to dabbling ducks in its flooded state than it was formerly, because of the larger shallow water area and the development of rice cutgrass, fig. 17, smartweed, fig. 16, wild millet, and other aquatic and moist-soil plants that furnish food for ducks.

Wood ducks (*Aix sponsa*) are the only wild waterfowl that nested in the area. Yearly observations by Frank C. Bellrose, Jr., and other members of the Natural History Survey staff indicate a severalfold increase in breeding and summer populations of these birds since 1938, apparently because of the greater area of attractive habitat. Nesting sites in the hundreds of hollow snags and trees are ample; and quiet, duckweed-covered waters in the flooded timberlands are probably ideal as rearing grounds. There was some evidence in 1946 of decreasing attractiveness of the area to wood ducks as a result of the opening up of flooded woodland and the trend toward the marsh stage of succession.

There was abundant evidence during much of the study period of a general increase in number of herons on the area. After 1941, a score or more of these birds could often be counted at a single stand, and, by including all of the concentration areas on the point, 500 to 700 herons could easily have been recorded in a day's time. On August 6, 1941, Harry G. Anderson, an ornithologist associated with the Natural History Survey, and the writer counted 200 American egrets (*Casmerodius albus egretta*), 12 snowy egrets (*Egretta thula thula*), and 40 great blue herons (*Ardea herodias herodias*) on one 20-acre bay. None of these birds is included in table 8. In June, 1941, four green heron (*Butorides virescens*) rookeries, averaging 20 nests each, were found in the course of routine work. Systematic coverage of the tract would probably have disclosed others. The 600 or more acres

of shallow water, abounding in minnows, small fish, frogs, crayfish, and other food, afforded excellent foraging grounds for all species of wading birds present.

With the appearance of marsh, breeding populations of red-wing blackbirds (*Agelaius phoeniceus phoeniceus*) became established in 1938. On May 15, 1942, Harry G. Anderson and the writer counted 22 red-wing nests in less than one-half acre of cattail marsh in Sawmill Slough, north of Coon Lake. This was near the middle of the area; other red-wing colonies were found in the various cattail stands along the Illinois River, Big Slough, and other places. The 10 red-wings noted on August 6, 1938, table 8, were in the vicinity of a cattail marsh at the mouth of Chickahominy Slough.

Highly suitable nesting and food conditions for woodpeckers were provided by the thousands of dead trees, in every condition of decay, on Calhoun Point. An increase of woodpeckers on the area was noticeable as early as October, 1939, following the death of numerous maple and other trees. As listed in table 8, at least six species were observed, of which the red-headed woodpecker (*Melanerpes erythrocephalus*) was most common. Next in numerical abundance was probably the red-bellied woodpecker (*Centurus carolinus*); the flicker (*Colaptes auratus luteus*) was third. An unusual number of pileated woodpeckers (*Ceophloeus pileatus abieticola*) were present, the writer observing 13 on the morning of October 14, 1944. At least six were in one scattered flock. Downy (*Dryobates pubescens*) and hairy woodpeckers (*D. villosus*) were other species recorded.

No attempt was made to determine the effect of flooding on perching birds. Such conspicuous forms as the prothonotary warbler (*Protonotaria citrea*) and American redstart (*Septophaga ruticilla*) were abundant on the area in years covered by this report. Harry G. Anderson and the writer recorded 45 of the former and 30 of the latter on May 15, 1942. A total of 66 species of birds were listed on that date, but it is certain that many of these were migrants. General evidence indicates that the prothonotary warbler, at least, increased over the population present on the area in 1938.

Starlings (*Sturnus vulgaris vulgaris*) were observed in considerable numbers on the area in October, 1946.

SUMMARY

1. Timber killed by impoundment of water for power development, channel improvement, flood control, and other purposes represents a problem of growing importance throughout the United States.

2. The effect of water impoundment on timber was studied over an 8-year period, 1939-1946, at the junction of the Mississippi and Illinois rivers, where sizable tracts of river-bottom timber were killed by the Alton Dam impoundment, first pooled in 1938.

3. The study area, Calhoun Point, consisted of 2,200 acres of river-bottom forest, sloughs, lakes, and small marshes. About 600 acres of this tract were flooded permanently by the Alton Dam, which raised the average summer water stage about 3 feet. This rise in level reduced the highest elevation on Calhoun Point from 10 to 7 feet above the average summer water surface.

4. Timber stands on the study area were all-age, river-bottom hardwoods characteristic of the upper Mississippi River valley. Silver maple was easily the dominant species; American elm, white ash, pin oak, pecan, river birch, cottonwood, black willow, persimmon, hackberry, and waterlocust were other common species. Important shrubs were buttonbush, waterprivet, and deciduous holly.

5. The effects of flooding were studied on sample areas, consisting of six 50-foot transects, aggregating 3.5 miles in length. These transects crossed all representative timber types on Calhoun Point. Individual trees in the sample were identified by numbered metal tags attached with galvanized nails at breast height. Records involving species, d.b.h., crown class, general vigor, depth flooded, and year of death were taken at intervals. A total of six inspections, in addition to the one at time of tagging, and numerous visits at other seasons, supplied the data for this report.

6. River stages, 1937-1946, at Grafon, Illinois, less than 2 miles downstream from the area, were studied in relation to

the rate of dying in tree species and succession in aquatic vegetation.

7. The effect of flooding on timber was studied under three categories: (1) timber actually flooded; (2) timber on sites where the water table had been raised to the ground surface; and (3) timber on unflooded land, where the average summer water table had been raised approximately 3 feet.

8. Eight years of actual flooding of timber areas resulted in practically complete tree mortality. In most tree species, flooding to a depth sufficient to cover the root collar, less than 20 inches, was fatal. Rate of dying showed wide variation by species. Pin oak was most susceptible to injury from flooding, all individuals of this species dying before or during the third year. White ash was most resistant, a few individuals giving rise to trunk sprouts 8 years after inundation. Mortality in most other tree species was 100 per cent in 6 years. Waterlocust showed a mortality of 96.0 per cent and black willow 43.5 per cent in 6 years; a few trees of these species were still alive 8 years after impoundment. All bur oak trees were dead 3 years after permanent flooding was begun; all persimmon, hackberry, hawthorn, river birch, and cottonwood were dead in little more than 4 years. Most silver maple was dead in about 4 years; all silver maple, American elm, and pecan were dead in about 6 years.

9. The three shrub (or small tree) species represented in the water sample likewise varied in tolerance to flooding. Deciduous holly showed 100 per cent mortality in about 4 years. Waterprivet, in October, 1946, more than 8 years after flooding, showed 85 per cent mortality; surviving individuals were in less than 2 feet of water. It appeared in 1946 that some of these would live. Buttonbush was definitely the most tolerant species sampled, this shrub showing a survival of 40 per cent or more except when deeply submerged.

10. The diameter of trees and shrubs subjected to flooding had little influence on their death rate. An apparent difference in the 2-inch class was due to species rather than to size. In general, within each species, healthy, vigorous trees showed the greatest resistance to flooding, and the

very small class (other than in semiaquatic species) and the overmature class showed the least resistance. The depth flooded (short of submersion) likewise appeared to make little difference, provided the root collar was covered. A depth of less than 20 inches was sufficient to cover the root collar of all species involved.

11. The harmful effect of a raised water table was clearly discernible, particularly where mud conditions were created, but, for each species, tree mortality was less severe in mud than in water. To mud, as to water conditions, pin oak was very susceptible and white ash very resistant; semiaquatic shrubs like waterprivet showed no mortality in mud.

12. On land above the mud level, but subjected to a 3-foot rise in the water table, only pin oak showed conspicuous reaction. Here, at the end of approximately 6 years, mortality among trees of this species had reached 28.2 per cent and was noticeably progressive. Losses in elm and maple were much lower, and white ash, pecan, cottonwood, and several other trees and shrubs apparently were unaffected by the increased water level.

13. Several tree species bore fruit under flooded conditions. This occurrence was most pronounced during the first 2 years. Only willow, waterlocust, waterprivet, and buttonbush produced fruit during the third year subsequent to inundation.

14. Trees with root systems flooded only on one side showed differential dying rates in parts of the same tree, the side inundated being nearly always the first to die.

15. Willow, white ash, and buttonbush showed marked ability to set adventitious roots during the first 2 or 3 years of flooding. Silver maple showed this ability to a lower degree.

16. The effect of flooding on forest reproduction was similar to that on parent trees. White ash reproduction showed by far the greatest tolerance to flood conditions.

17. Falling of dead timber became noticeable 3 years after flooding; it was advanced 6 years afterward, and extremely pronounced 8 years afterward. Pin oak showed greatest resistance to trunk fall; other species, without durable heartwood,

snapped off at varying distances along the trunk.

18. Dead timber falling on the study area became waterlogged or deeply embedded in mud. Few falls reached the Mississippi and Illinois rivers to offer hazards to shipping and commercial fishing.

19. By 1946, conversion to marsh of the flooded bottomland, then a jumble of fallen logs and debris lying in mud and shallow water, had begun. Cattail, duckpotato, and various sedges were the most common marsh invaders; smartweed, wild millet, and rice cutgrass held a similar position on moist soil.

20. Extremely heavy growths of coontail and leafy pondweed, often covered in the fall by a mat of duckweed, appeared in the clear-water sloughs and lakes during the first 4 years of flooding.

21. Floods, several feet above normal pool stage in 1943, 1944, and 1945, destroyed practically all submerged and emergent aquatic vegetation, but, by the fall of 1946 several species showed evidence of recovery.

22. Reproduction of river-bottom tree species was common in 1944, and, in 1946, seedlings of maple, elm, ash, willow, cottonwood, pin oak, and pecan were growing vigorously.

23. Among mammals, muskrats showed great adaptability to conditions induced by flooding. The severe floods of 1943 and 1944, and a lesser flood in 1945, apparently depleted their numbers, but there was evidence of recovery by October, 1946. Opossums and cottontail rabbits were apparently evicted from the area by the series of high waters.

24. Raccoons and minks, with some fluctuations in populations, remained common to abundant in the area throughout the period of study.

25. Land mammals, such as woodchucks, skunks, and foxes, found less and poorer habitat on the area after flooding in 1938 than previously. The 3-foot rise in the water table undoubtedly limited the area suitable for ground dens on this low flood plain.

26. Flooding improved the Calhoun Point habitat for wood ducks, herons, and woodpeckers, and was attended by noticeable increases in the populations of these three groups. The increase was perhaps

most conspicuous in woodpeckers, for which the thousands of dead and dying trees provided unlimited food and nesting sites. The development of cattail marsh was accompanied by increases in the number of nesting red-wing blackbirds. Considerable numbers of starlings were observed on the area in 1946.

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HARLOW B. MILLS, *Chief*

Canada Geese of the Mississippi Flyway

*With Special Reference
to an Illinois Flock*

HAROLD C. HANSON

ROBERT H. SMITH

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Volume 25

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This paper is a contribution from the Section of Game Research and Management.

FOREWORD

OF all of the geese inhabiting North America, the Canada goose stands at or near the top of the list in general recognition, and as a game bird. So well known is it that the mention of wild goose brings to the average person a mental picture of the great gray-bodied, black-necked, white-jowled "honker." Francis Kortright, in his *The Ducks, Geese and Swans of North America* says, "Sagacity, wariness, strength and fidelity are characteristics of the Canada Goose which, collectively, are possessed in the same degree by no other bird." The cold, calculating, investigative, scientific eye may occasionally cast doubt on the completeness with which some of these traits permeate the whole population (as will be noted in this report). One can, if he searches diligently, find a thriftless Scotchman.

Wide distribution, great size, and habits conspicuous to the ear and eye have all assisted in making the Canada goose a well-known bird; but most of the knowledge concerning it has been general and superficial. During some time in the year this goose may be seen from one coast to the other and from northern Canada to the Gulf of Mexico. To the average person this wide distribution might mean that the elimination of the species from any of its areas of habitation would be difficult. But every field biologist is familiar with the so-called "flyway concept" that has developed in the past few decades. This concept, backed by a large quantity of band-recovery data and general observation, is that the whole population of a migratory species may be divided into subpopulations, each having rather definite nesting and wintering areas and routes of movement, with a minimum of mixing among these subpopulation groupings.

On the basis of this thinking, the study of a migratory species breaks down into a number of geographic units, and the success or failure of one flyway population may affect but little the populations of other flyways.

This is the problem that faced those interested in the geese wintering in Illinois. From nesting grounds on the west side of James Bay in Canada, one segment of the Canada goose population moved south and west, and in recent years wintered to a very large extent at the Horseshoe Lake Game Refuge in Alexander County, Illinois. About half of the population of geese in the Mississippi flyway concentrated in a small area where excessive hunting could conceivably have affected numbers and hunting successes in a very large area both inside and outside the state. The object of the study reported herein was to ascertain the health of the Horseshoe Lake population, and this study required a broad attack both as related to the subject matter investigated and the geography involved.

Both of the authors have been far afield in this study. Mr. Smith, as Flyway Biologist for the United States Fish and Wildlife Service, has had an opportunity allowed to but a very few to observe this and other Canada goose populations. Mr. Hanson spent several years at Horseshoe Lake and parts of two summers in the James Bay nesting area.

The section titled "Population Survival" represents an attempt to analyze a difficult problem with data difficult to obtain in quantity. The data available have been explored by Mr. Hanson, and certain conclusions reached. These conclusions, it is realized, may vary somewhat from the true picture, but it is felt that their inclusion is worth while as a stimulus to a fuller investigation of this problem even if there were no other values accruing.

A study such as the following must of necessity have authors. It is obvious, however, that an investigation of this magnitude is the result of the authors' efforts plus assistance from many people in numerous ways. To all who helped in any way we are deeply grateful.

HARLOW B. MILLS, *Chief*
Illinois Natural History Survey

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Evening flight of Canada geese at Horseshoe Lake.

Canada Geese of the Mississippi Flyway

*With Special Reference
to an Illinois Flock*

HAROLD C. HANSON

ROBERT H. SMITH*

HORSESHOE LAKE, formed from an ancient oxbow of the Mississippi River, lies in Alexander County, Illinois, at the southwest tip of the state, fig. 1. An area, totaling 3,489.77 acres, that includes the lake and the island it surrounds, was purchased by the Illinois State Department of Conservation in 1927 for use as a wildlife refuge. Subsequent purchases in 1941, 1945, and 1946 added about 220 acres to the area, now known as the Horseshoe Lake Game Refuge.

That the plan of use for the Horseshoe Lake area was eminently successful from the standpoint of attracting wildlife soon became evident. Flocks of Canada geese that previously had wintered along the Mississippi River in the region of southern Illinois left their traditional wintering grounds for the food supply and the rest lake provided by the refuge. In recent years, for varying periods during the autumn and winter, the Horseshoe Lake Game Refuge and the countryside immediately around it have contained approximately 50 per cent of the Canada goose population wintering in the entire Mississippi River valley.

Along with the increase in numbers of Canada geese at Horseshoe Lake there were two developments of primary importance: a tremendous increase in shooting pressure on the flock and an alteration in the behavior of the geese. Once as wary as any waterfowl population in

the Mississippi River valley, the goose flock using Horseshoe Lake gradually lost most of its fear of man and gunfire while near the refuge. The obvious result of the greatly increased shooting pressure and the loss of normal wariness was a tremendous increase in the kill.

Large annual kills made at Horseshoe Lake, beginning in 1939, focused the attention of wildlife administrators on the need for a long-term management program in that area. In recognition of this need, the Natural History Survey Division of the Illinois State Department of Registration and Education instituted the research program on which the present report is based. When it became evident that the Horseshoe Lake goose problem was not only of local importance, but national and international in scope, the United States Fish and Wildlife Service initiated a program of investigations to cover the entire range of the Canada goose population wintering in the Mississippi River valley; these investigations extended from the James Bay region of Canada to the coastal marshes of Louisiana.

ACKNOWLEDGMENTS

For the generous co-operation on the research project at Horseshoe Lake by the Illinois Department of Conservation, the agency which operates and maintains the refuge, special appreciation is due officials or employees of the Department active during the period of field work:

* Flyway Biologist, United States Fish and Wildlife Service.

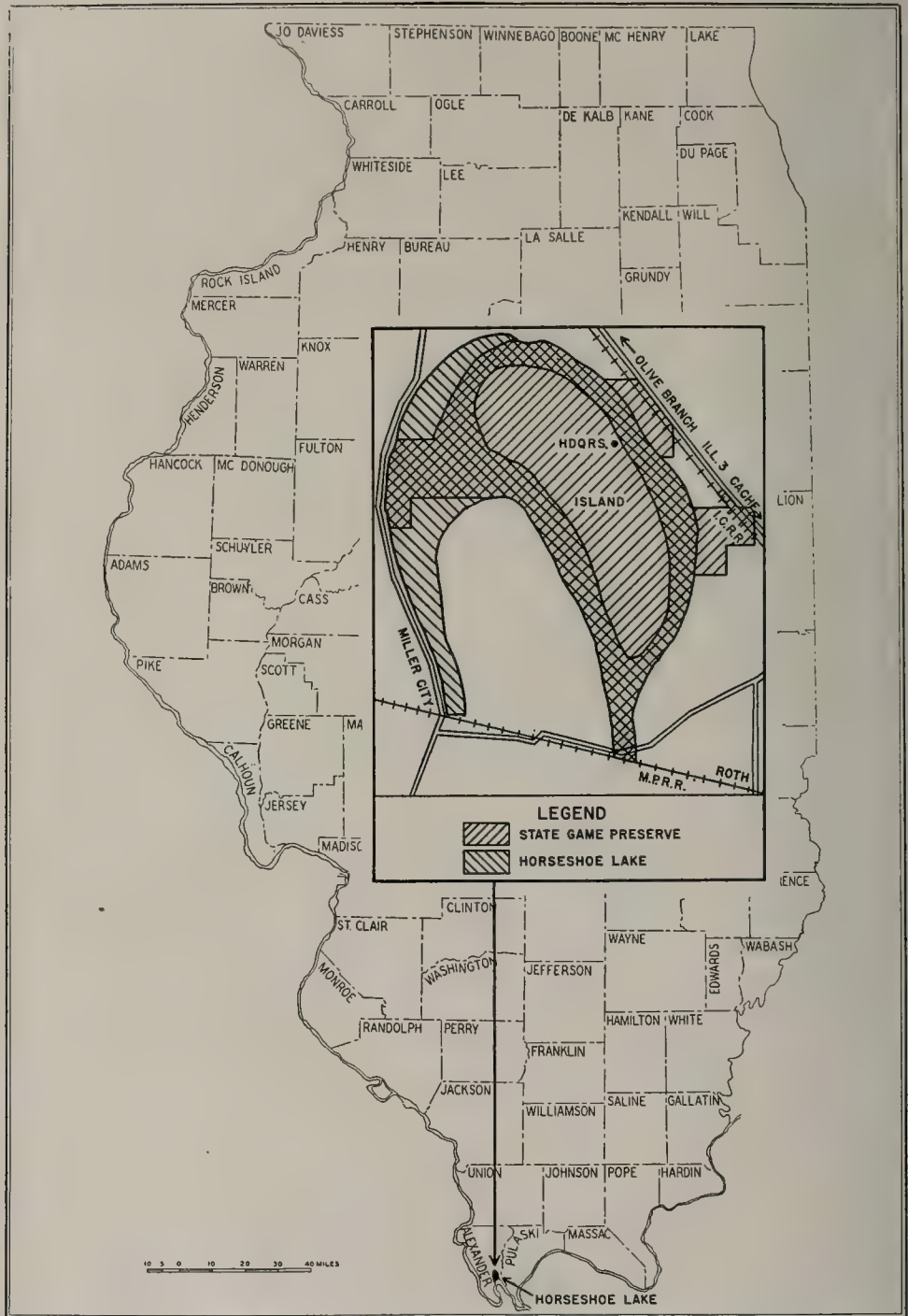


Fig. 1.—Map showing the boundaries and location of the Horseshoe Lake Game Refuge, 1946. The refuge area totaled about 3,700 acres at the end of that year. The original purchase, in 1927, involved about 3,500 acres.

Livingston E. Osborne, Director; Lewis E. Martin, Harold L. Gray, and Joe B. Davidson, members of the administrative staff; and Vernal Nave, C. E. Laughery, and Kenneth Long, refuge managers. The inception of the Canada goose study at Horseshoe Lake was in no small measure due to Paul S. Smith, formerly Chief Conservation Officer, Illinois Department of Conservation, and later Game Management Agent of the United States Fish and Wildlife Service. He was one of the first to recognize the serious consequences of the high Canada goose kills in southern Illinois and to awaken others to its dangers. The valuable co-operation given the research program by Smith was continued by his successor, Vernon C. Conover.

For their official helpfulness and personal interest in the research program, we are indebted to the late Dr. Theodore H. Frison, formerly Chief, to Dr. Leo R. Tehon, formerly Acting Chief, and to Dr. Harlow B. Mills, present Chief, of the Illinois Natural History Survey; to Dr. Clarence Cottam, Fredrick C. Lincoln, Jesse F. Thompson, Leo Couch, Dr. Gustav A. Swanson, and Richard Griffith, all of them during the period of field work with the United States Fish and Wildlife Service; to Dr. Harrison F. Lewis and T. S. Hennessey of the Dominion Wildlife Service, Canada Department of Mines and Resources; and to Dr. T. J. Orford of the Indian Affairs Branch, Canada Department of Mines and Resources.

Manly Miner, President of the Jack Miner Migratory Bird Foundation, Inc., acting in behalf of the Miner family and the Miner Foundation, was most helpful during the course of this study. For permission of the Miner family to compile and analyze the Miner goose-banding records, we are deeply appreciative.

The senior author was privileged to undertake field studies in the James Bay area in 1946 and 1947 under the auspices of the Arctic Institute of North America. For helpfulness in connection with this activity we wish to thank Dr. A. L. Washburn, Executive Director of the Institute.

In 1947, Ducks Unlimited provided the senior author with funds for an aerial reconnaissance of the breeding grounds of the Canada goose in northern Ontario and

northeastern Manitoba. Appreciation is due for the support given this program by L. H. Barkhausen, B. W. Cartwright, and Arthur Bartley. Paul Queneau of Westport, Connecticut, rendered valuable assistance during these flights by operating one of the aerial cameras used and keeping a personal flight log of his observations.

We are grateful to Father John M. Cooper of the Catholic University of America for permission to quote from his unpublished report on tribal and family hunting grounds in the James Bay area and to reproduce a portion of his accompanying map, fig. 9. This report, on file in the Indian Affairs Branch, Canada Department of Mines and Resources, was made available to us through the courtesy of T. R. L. MacInnes.

Employees of the Hudson's Bay Company and other residents of the James Bay area have shown us many courtesies and contributed information. We are indebted to William B. Anderson, W. J. Cobb, Mathew Cowan, R. M. Duncan, William Faries, C. C. Forman, William Glennie, Patrick Houston, Wesley Houston, A. H. Michell, Father Leopold Morin, Thomas Rettalack, Norman Ross, Arthur Sullivan, and the late James Watt and Mrs. Watt. The above people, as well as the following, have zealously reported bands in past years: J. W. Anderson, Bishop Henri Belleau, Father Bilo-deau, George S. Cotter, H. Gibbs, the Rev. Arnold C. Herbert, Brother Gerard Lavoie, the Rev. D. A. MacLachlan, Norman Mathew, L. G. Maver, P. A. C. Nichols, E. H. Riddell, the Rev. H. A. Turner, the Rev. J. H. Turner, J. B. Tyrer, and Harold Udgarden.

For information on the wintering grounds and kills of Canada geese in various states we are indebted as follows: for Michigan, Herbert J. Miller and Dr. Miles D. Pirnie; for Wisconsin, Therman Deerwester and F. R. Zimmerman; for Minnesota, Frank D. Blair; for Indiana, William B. Barnes; for Iowa, Bruce F. Stiles; for Missouri, M. O. Steen. Data for other states have been gathered largely by the authors, but Frank C. Bellrose of the Illinois Natural History Survey has furnished us with the information on Canada goose concentrations in the Illinois River valley.

From 1940 through 1943, staff members of the Illinois Natural History Survey carried out studies of a captive Canada goose flock on the Bright Land Farm near Barrington, Illinois, a program supported by the late A. L. Eustice and Mrs. Eustice, aided by Carleton A. Beckhart.

Cecil S. Williams, Dr. Elizabeth Brown Chase, Arthur S. Hawkins, and Dr. Gustav A. Swanson have read parts of the manuscript and given much helpful criticism. Dr. Chase and H. W. Bean have reviewed the statistical data. Arlone Hanson has contributed much valuable assistance in the field and in the office.

MATERIALS AND METHODS

This Canada goose study is based on data from three primary sources: data collected at Horseshoe Lake, Alexander County, Illinois; surveys by the authors on the distribution, habitat, and behavior of the population elsewhere in the Mississippi flyway; and banding records of the Jack Miner Bird Sanctuary, Kingsville, Ontario. Data from other sources have been used as indicated in the text.

Data From Horseshoe Lake

Most of the data relating to Canada geese of the Horseshoe Lake Game Refuge, prior to 1940, were obtained by Paul S. Smith when he was federal Game Management Agent. In 1940 and 1941, Arthur S. Hawkins, then Game Technician of the Illinois Natural History Survey, collaborated with Smith on an investi-

gation of conditions at and near Horseshoe Lake. The first successful trap used at Horseshoe Lake was designed and constructed by John M. Anderson and Jacob H. Lemm of the Natural History Survey and in February, 1941, the first bandings of geese in the area were made by Hawkins, who recorded the sex and age classes of birds banded. In January and February, 1942, and in the winter of 1942-43, Dr. William H. Elder continued the trapping program begun by Hawkins. From the autumn of 1943 to the spring of 1947, the senior author was responsible for the research program at Horseshoe Lake.

In the studies at Horseshoe Lake, particular emphasis was given to trapping and banding (Hanson 1949c), often the only techniques whereby such vital statistics as average longevity and rate of population turnover can be obtained. These study techniques yielded data on sex and age composition of the flock, and, in connection with bag inspection, on the differential vulnerability of the sex and age classes. Sex and age criteria, flock habits and flock organization, crippling losses, and, as time permitted, diseases and parasites of Canada geese were also studied. The total numbers of Canada geese trapped and banded at Horseshoe Lake by the Illinois Natural History Survey are given in table 1.

Data From Jack Miner Sanctuary

On a number of occasions, members of the Illinois Natural History Survey staff

Table 1.—Number of Canada geese trapped at Horseshoe Lake, Alexander County, Illinois, by Illinois Natural History Survey personnel, during the fall and winter seasons of 1940-41 through 1946-47.

SEASON OF TRAPPING	GEESE BANDIED	RETURNS RETRAPPED *	TOTAL INDI- VIDUALS	REPEATS AND RETURNS RETRAPPED*	TOTAL ANNUAL CATCH
1940-41.....	315	0	315	11	326
1941-42.....	402	6	408	24	432
1942-43.....	1,036	18	1,054	147	1,201
1943-44.....	2,329	133	2,462	2,139	4,601
1944-45.....	853	248	1,101	1,567	2,668
1945-46.....	310	231	541	543	1,084
1946-47.....	502	215	717	289	1,006
Total.....	5,747	851	6,598	4,720	11,318

*A return is a goose trapped and banded at Horseshoe Lake that is retrapped at Horseshoe Lake in any year following the year of banding. A repeat is a goose trapped and banded at Horseshoe Lake that is retrapped at Horseshoe Lake in the year of banding, or a return that is retrapped more than once in any year.

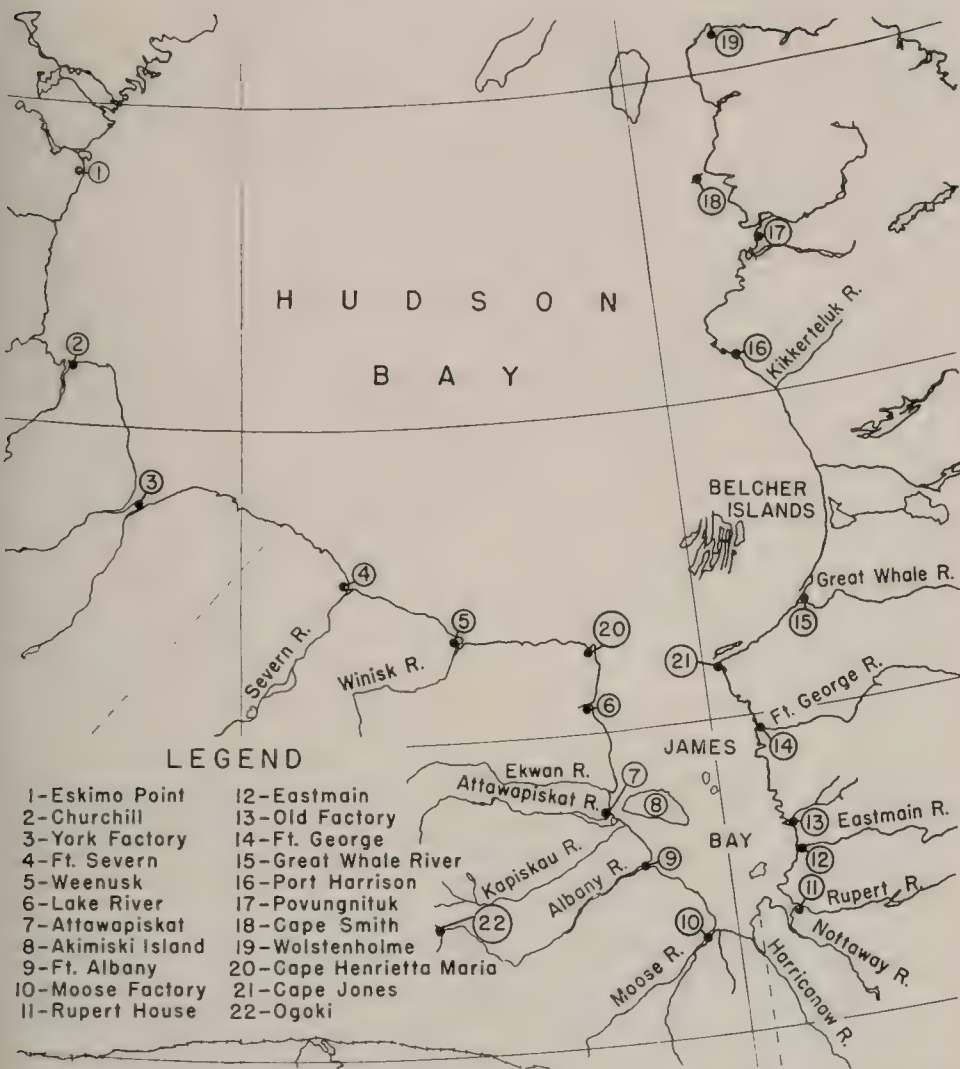


Fig. 2.—Map of the Hudson-James Bay range of Canada geese that winter in the Mississippi River valley. The main breeding range of this goose population is between the Severn and the Albany rivers.

have visited the Jack Miner Bird Sanctuary at Kingsville, Ontario, to study trapping operations. The first traps built at Horseshoe Lake, although set on land, were modeled after the water trap perfected by the Miners. In May, 1945, the authors visited Kingsville to obtain background material requisite for compiling and interpreting Miner band-recovery data. The Miner records consisted of the original reports of band recoveries from hunters in the United

States and Canada, and from missionaries and fur traders in the far north, who reported recoveries made by the natives. The senior author was responsible for the compilation of these original data, which are filed in Ottawa at the Dominion Wildlife Service, Canada Department of Mines and Resources.

Between 1915 and the spring of 1944, approximately 31,000 Canada geese were banded at the Miner Sanctuary. From these bandings approximately 3,900 rec-

Table 2.—Number of Canada geese banded at the Jack Miner Bird Sanctuary, Kingsville, Ontario, during the fall trapping seasons, 1927–1944.

YEAR	GEESE BANDED	YEAR	GEESE BANDED
1927.....	50	1936.....	660
1928.....	558	1937.....	1,741
1929.....	225	1938.....	604
1930.....	578	1939.....	1,606
1931.....	1,091	1940.....	1,182
1932.....	1,129	1941.....	1,235
1933.....	1,490	1942.....	1,167
1934.....	468	1943.....	1,294
1935.....	170	1944.....	984
<i>Total.....</i>		<i>16,232</i>	

ords of recoveries had been received by 1944. Although exact records are not available for the early years, it is estimated that about one-half of the 31,000 geese were banded in the autumn months, table 2, when many geese of the Mississippi flyway migrate through the Kingsville region. A comparatively small number of

the geese of this flyway migrate through Kingsville in spring. Recovery records from fall-banded geese for which sufficient data are available have been analyzed for use in this paper.

Because of their sheer mass and the span of years they cover, data from the Miner bandings are outstanding in the annals of wildlife study. That the bandings have not yielded findings commensurate with their size is understandable, as they were begun at a time when little was known about sexing and aging of Canada geese.

Because Jack Miner did not serially number his bands, some of the potential values of his bandings will never be realized. Prior to 1932, his bands were marked with symbols to represent only the season and year in which they were used. For example, "25 S" meant 1925 spring; "25 F" meant 1925 fall. Since 1932, all bands have been stamped with an additional letter to signify the date of banding, and, since the fall or autumn of 1946, all bands have also been serially numbered.



Fig. 3.—Noon stop on the Albany River, June 1947. Canoe and plane are the only means of travel in much of the breeding range of the Mississippi Valley geese.

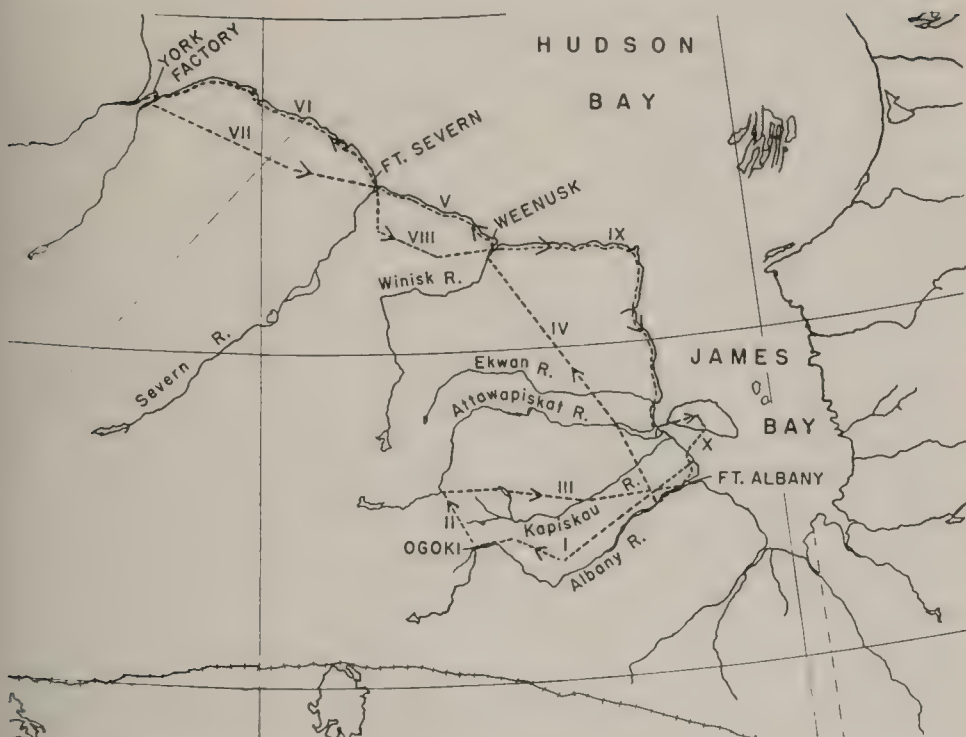


Fig. 4.—Map showing flight routes of an aerial reconnaissance of the breeding grounds of Canada geese south of Hudson Bay and west of James Bay in 1947. Roman numerals designate the various flights discussed in the text.

Recovery records for the first 8 years are incomplete, as many of the letters reporting bands were given to newspapers and never returned. In some cases only news clippings with incomplete data served to preserve early records.

Data From Other Areas

Field studies on Canada goose concentrations away from Horseshoe Lake were begun by the junior author in 1942. Beginning in 1943, he inventoried by plane many of the wintering concentrations from Horseshoe Lake to Louisiana. He devoted the summer of 1943 to a survey of the south and east coast areas of James Bay, from Moose Factory, Ontario, to Fort George, Quebec, fig. 2. The following summer he made a reconnaissance of the west coast from Moose Factory to Cape Henrietta Maria.

The senior author made a brief preliminary trip to James Bay in the summer of 1946, visiting Moose Factory, Rupert

House, and Fort Albany, and ascending Little Partridge Creek via canoe. In 1947, he spent from mid-May to September investigating the breeding grounds inland from the west coast of James Bay; he used both canoe, fig. 3, and plane for these surveys. The aerial reconnaissance in 1947 included stops at Weenusk, Fort Severn, and York Factory. Approximately 375 aerial photographs were taken on this aerial survey, the itinerary of which is shown in fig. 4.

Data From Questionnaires

Approximately 40 questionnaires regarding goose-breeding grounds and kills were distributed to fur trade posts in the Canadian Eastern Arctic in 1947, through the courtesy of the administration of the Northwest Territories, Canada Department of Mines and Resources. Replies to the questionnaires have been summarized and the data included in this report.

THE FLYWAY CONCEPT

Over a decade ago, Lincoln (1935) presented the concept that the routes taken by North American birds in migration fall into major flyways or lanes of travel. Recoveries of banded birds have demonstrated the validity of the flyway concept with respect to waterfowl as well as many other kinds of birds. Lincoln named the Atlantic, the Mississippi, the Central, and the Pacific flyways as the principal ones of North America.

The limits of the waterfowl flyways vary somewhat with each species and may change to some degree from year to year, depending on weather, surface water, and food conditions. In most species the populations of one flyway merge almost imperceptibly with those of adjoining flyways. Consequently, the flyway taken in any one year by an individual bird breeding in an area where two flyways meet may be due in part to chance.

The adherence of ducks and geese to their ancestral flyways has been demonstrated experimentally by removing individuals from one flyway to another. With relatively few exceptions, the transported individuals have been recorded later in their original flyways. One of the early experiments of this kind with ducks was begun in 1918 by McIlhenny (1940), who, in co-operation with Dr. Arthur A. Allen of Cornell University and the United States Bureau of Biological Survey, shipped ducks and coots trapped during the winter in Louisiana, which is in the Mississippi flyway, to points in the Atlantic and Pacific flyways. Most of the released individuals that were later recovered or retrapped were taken in the Mississippi flyway.

Perhaps the earliest test of this kind with Canada geese was made by Jack Miner; complete data on the test were found in the files of the Dominion Wildlife Service. In the spring of 1934, 25 geese trapped at the Miner Sanctuary, from flocks that had wintered on the Atlantic Coast and were in migration to their breeding grounds along the east coast of James and Hudson bays, were released among a concentration of blue and snow geese at Grant Lake, Mani-

toba, a locality far west of their own migration routes. Three of these geese were later reported shot, two of them in their own flyway: one in the vicinity of Poplar Branch, North Carolina, in the fall of 1934; the other near Lake St. John, Quebec, in the fall of 1940. The third was recovered in northern Manitoba in the spring of 1934, too soon after release for the record to be significant.

The chief deviations from flyway consciousness are among young birds that have not yet nested (Lincoln 1934). Williams & Kalmbach (1943) showed that the migratory behavior of young Canada geese when raised in or transported to a new area is similar to the behavior of geese native to that area.

As pointed out by Lincoln (1935), the adherence of waterfowl to their ancestral flyways has particular administrative significance in connection with conserving the continental waterfowl resources. "It indicates," Lincoln writes, "that if the birds should be exterminated in any one of the four major flyways now definitely recognized, it would at best be a long time before that region could be repopulated, even though birds of the species affected should continue over other flyways to return to their great breeding grounds of the North."

This hypothesis is of special significance as applied to the management of Canada geese. Members of a species with a fairly low breeding potential, they would probably require several years to regain their numbers in any one flyway after having been once seriously depleted. Thus, it is to the hunter's best interests that the yearly kills in each flyway be kept within reasonable bounds.

EASTERN POPULATIONS

A brief review of the distribution and taxonomy of Canada goose populations in eastern North America is relevant to an understanding of the data later presented concerning the Mississippi flyway population.

The Canada geese using the Atlantic and Mississippi flyways, as defined by Lincoln (1935), have been recognized as belonging to two distinct major populations, based on taxonomy (Todd 1938)



Fig. 5.—Extreme examples of plumage variation in Canada geese of the flock wintering at Horseshoe Lake in southern Illinois. The majority of the geese at Horseshoe Lake approach the dark-colored goose, left above, considered to be *Branta canadensis interior*; but a few resemble the individual at the right. The latter is more like *Branta canadensis canadensis* of the North Atlantic coast. The goose on the left is a yearling female; that on the right, a yearling male.

and location of the breeding grounds: the North Atlantic population and the Hudson-James bay population. The North Atlantic population constitutes a distinct management unit. The study reported here indicates that the Hudson-James bay population is not homogeneous but consists of four subpopulations, each of which constitutes a separate management unit having a fairly distinct range of its own. These subpopulations are here designated by terms suggestive of their wintering grounds or migration routes: the South Atlantic, the Southeast, the Mississippi Valley, and the Eastern Prairie.* The ranges of these subpopulations are shown in fig. 6.

Todd (1938) noted what he considered significant plumage differences among

Canada geese collected in the eastern half of the United States and proposed a new subspecies, *Branta canadensis interior*, for the darker colored birds that breed and migrate in an area west of the range of the nominate subspecies, *Branta canadensis canadensis*. Fig. 5 shows two Canada geese trapped at Horseshoe Lake with plumages that illustrate some of the differences between these two races.

"Typical *canadensis*, as represented by breeding examples from Newfoundland and by winter birds from the South Atlantic coast, is a comparatively light-colored bird," according to Todd (1938). "In breeding dress the anterior under parts are buffy white, and this pale color runs up on the sides of the lower neck (behind the black) to form a conspicuous light-colored area on the upper back. In the new race this feature is wanting. The feather-edgings of the new

* Name and recognition of the Eastern Prairie population as a separate population from Cecil S. Williams of the United States Fish and Wildlife Service, 1946.

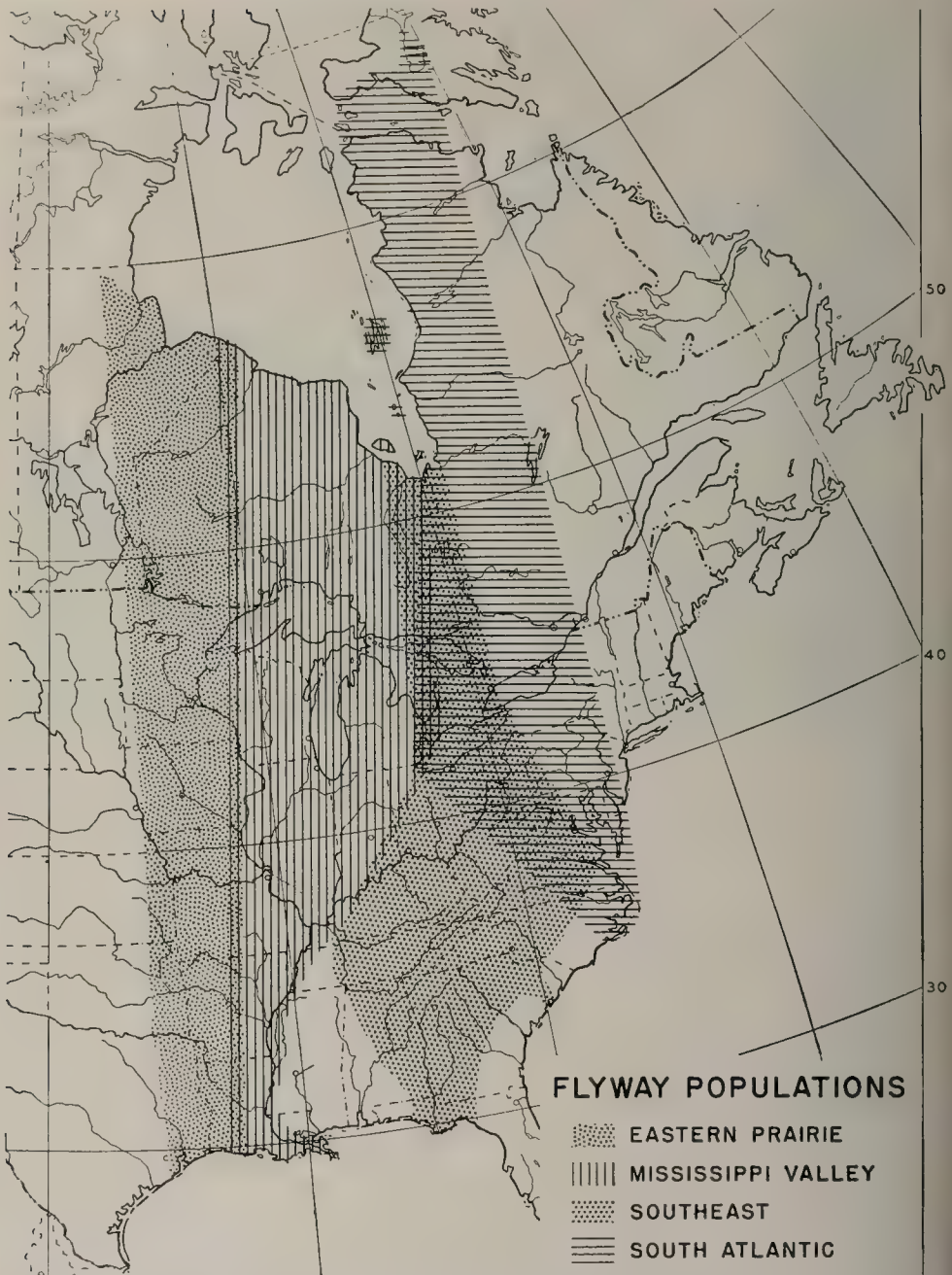


Fig. 6.—Map showing roughly the main ranges of the four populations of Canada geese nesting in the Hudson-James bay region. The range of the Mississippi Valley geese overlaps the range of the Southeast population chiefly in fall; the range of the South Atlantic population overlaps the range of the Southeast population chiefly in spring. The western limits of the range of the Eastern Prairie population extend farther west than indicated here. The eastern limits of the range of the South Atlantic population probably extend farther east in some areas than indicated.

race are generally darker, while the under-plumage is conspicuously so."

Official recognition was given to the race *interior* by its inclusion in the *Twentieth Supplement to the American Ornithologists' Union Check-List of North American Birds* (Wetmore 1945). Appendix B contains a brief summary of the latest classification of the Canada geese of the genus *Branta*, with notes regarding recognition of various kinds by the Indians.

North Atlantic Population

The Canada geese of the North Atlantic, which breed in Newfoundland, eastern Quebec, and Labrador north to the northern limit of trees (Austin 1932), are those recognized by Todd (1938) as *Branta canadensis canadensis*. In the autumn, they migrate down the Atlantic Coast and winter principally from Port Joli and Port l'Hebert, Nova Scotia (Tufts 1932, Lloyd 1923), to Martha's Vineyard, Massachusetts, and south probably as far as New Jersey. Skins examined by us at the Chicago Natural History Museum indicate that some of these geese winter as far south as the coast of North Carolina, where they mingle with South Atlantic geese.

Low (1935), in a report on 64 Canada geese banded at Cape Cod, Massachusetts, presented convincing evidence that the flight of geese along the North Atlantic Coast is a distinct entity. Twenty-five of the 26 geese later recovered or recaptured were taken between Newfoundland and New Jersey. One was recovered in Florida.

Hudson-James Bay Populations

The Canada geese that breed inland from both coasts of Hudson and James bays, fig. 2, as far north on the west coast as Churchill, Manitoba, and probably as far north on the east coast as Baffin Island, which lies just north of Cape Wolstenholme, conform to the description given by Todd (1938) for *Branta canadensis interior*. While the distribution of geese breeding around the two bays is more or less continuous, available data indicate that this population is a heterogeneous one and is composed of the four segments or subpopula-

tions previously named: the South Atlantic, the Southeast, the Mississippi Valley, and the Eastern Prairie. Each has its own breeding range, migration routes, and wintering areas, figs. 6 and 7. The existence of two of the population divisions that nest in the Hudson Bay area, one wintering along the central Atlantic Coast and the other in the Mississippi River valley, was first pointed out by Manly Miner (1931). This discovery, based on band recoveries, was due in part to the fortuitous location of the Miner Sanctuary, fig. 12, which lies about midway between the migration routes of these populations and thus permits banding of both populations.

South Atlantic Population.—This population is distributed in winter along the Atlantic Coast from southern New Jersey to Chesapeake Bay, Back Bay (Virginia), Pamlico Sound, and Currituck Sound, and Hyde and Dare counties, North Carolina. Recoveries from geese migrating through the Miner Sanctuary in the spring, and banded there in that season, reveal that Lake Mattamuskeet in Hyde County, North Carolina, has in recent years become the most important wintering area of this population.

A portion of the birds in this population stop at the Miner Sanctuary while en route to their breeding grounds, which are on the Belcher and probably the Twin Islands and in suitable localities along the east coast of James and Hudson bays, and inland probably to the height of land, as suggested by Todd (1938). Band recoveries indicate that the breeding range may include a portion of southern Baffin Island, fig. 7. Large numbers of recoveries reported from a post or small area may actually have been taken along extensive areas of the coast. For instance, recoveries plotted as from the Belcher Islands in fig. 7 also include the recoveries from the east coast of Hudson Bay from Cape Jones to Nastapoka Falls; recoveries represented as from the Port Harrison area actually include the recoveries made along the east coast of Hudson Bay from the Kikkerteluk River area to the Povungnituk area.

Southeast Population.—The existence and range of the Southeast population was revealed when band recoveries

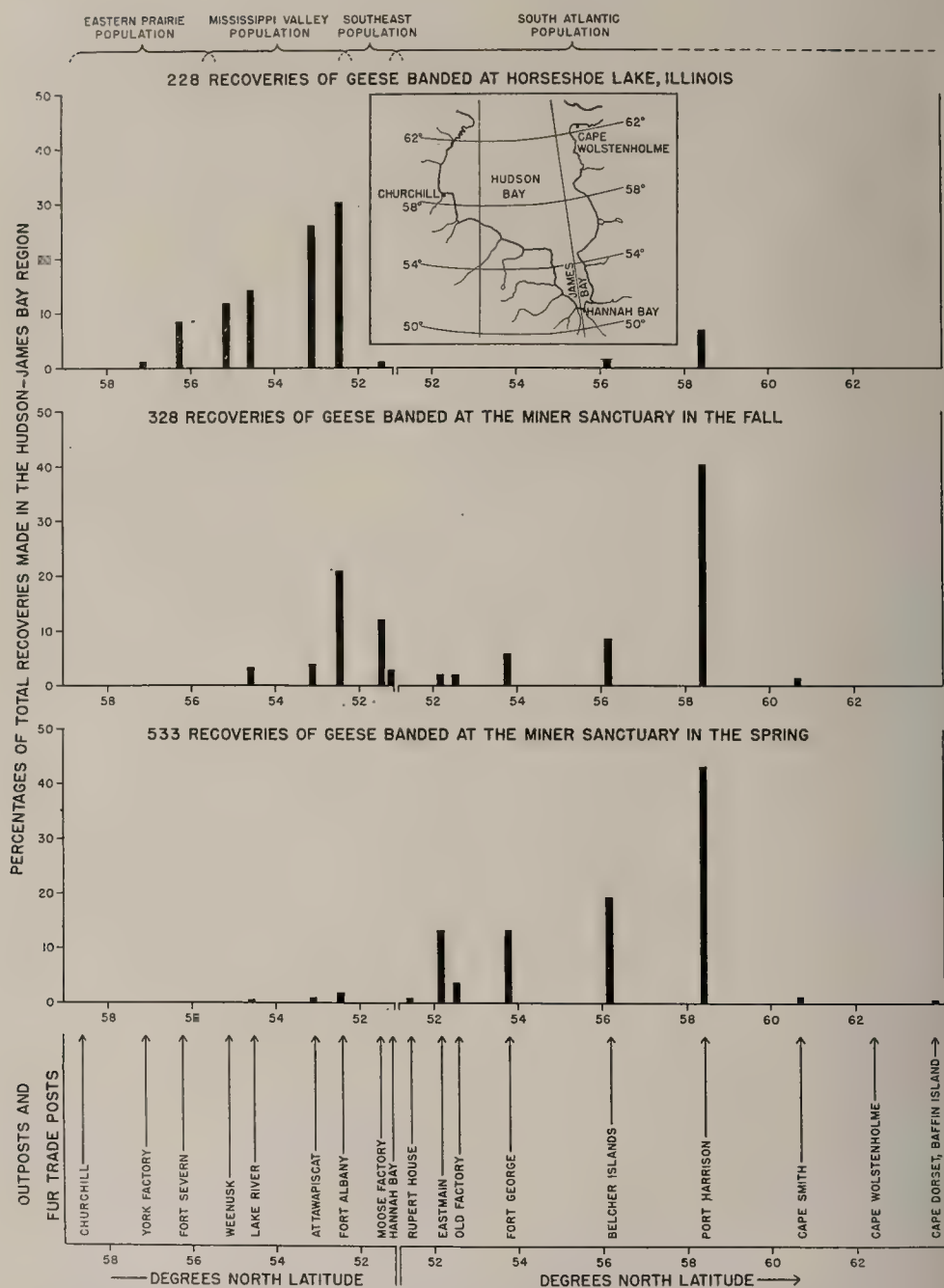


Fig. 7.—Band recoveries in the Hudson-James bay region from Canada geese banded at the Horseshoe Lake Game Refuge and at the Jack Miner Bird Sanctuary. Shown here are the percentages of the total recoveries from the Hudson-James bay region for various outposts and fur-trade posts. In some cases, large numbers of recoveries reported from a post or small area have actually been taken along extensive areas of the coast line. For instance, recoveries plotted as from the Belcher Islands also include recoveries from the east coast of Hudson Bay.

from the Miner autumn-banded geese were plotted as to exact locality. These recoveries show that the autumn flight of geese through the Kingsville, Ontario, area is not homogeneous, but is composed of two populations of geese: the Southeast population and the Mississippi Valley population, figs. 6 and 7. The Southeast population breeds inland from the south coast of James Bay and winters in the inland regions of the southeastern states. A detailed discussion of the range of the Southeast population is presented in Appendix A.

Mississippi Valley Population.—

The range of the Canada goose population that winters in the valley of the Mississippi River extends in autumn and winter from western Michigan west through the eastern portions of those states lying immediately west of the Mississippi River and south in the valley of this river to the coast of the Gulf of Mexico. The main winter range south of Cairo, Illinois, does not extend greatly beyond the immediate valley of the Mississippi River except in Arkansas and Louisiana. The Mississippi Valley population, which is given primary consideration in this paper, breeds inland from the west coast of James Bay and the south coast of Hudson Bay, figs. 6 and 7.

Eastern Prairie Population.—The eastern range limits of the Eastern Prairie population seemingly merge with the western range limits of the Mississippi Valley population on the breeding grounds in the muskeg between Fort Severn and Fort York and on the wintering grounds in western Louisiana, figs. 6 and 7. The eastern range limits of the Eastern Prairie geese in migration are apparently in central parts of Minnesota, Iowa, Missouri, Arkansas, and Louisiana. We do not have the data at hand to discuss the western limits of the range of this population, nor are they of concern in this paper.

HUDSON-JAMES BAY BREEDING RANGE

The Canada goose has long been a staple food item for the natives of North America. To the white man in the United States and Canada, it has been a highly

prized hunting trophy as well as an esteemed table bird. Formerly the species nested over much of the upper Mississippi River valley (McClanahan 1940), but, subjected to intensive hunting pressure, it was soon extirpated as a breeding bird from most of this country. Probably the only reason that there are still Canada geese to winter in the Mississippi River valley is that much of the country adjacent to Hudson and James bays in northern Ontario, where most of this migratory population breeds, is relatively inaccessible to man in summer.

Limits of Range

The general limits of the range of the Canada goose in the Hudson-James bay area have not been adequately summarized in previous publications. The existence of only two of the four populations that nest adjacent to these bays has been recognized previously, and the limits of their ranges have not been well defined. For these reasons, in addition to presenting new data on the Canada goose breeding range in the region of Hudson and James bays, we review pertinent references in the literature.

Until the race *Branta canadensis interior* was recognized by the American Ornithologists' Union (Wetmore 1945), most of the writers who mentioned the Canada goose either made no distinction between the two races of *Branta canadensis*, or they referred to birds of both races as belonging to the race *canadensis*. References in the literature prior to 1945 to either of these races should be interpreted in the light of the recent decision by the A.O.U.

The sequence of the following citations is in general according to the geographic position of the localities concerned: from north to south on the west side of the bays and from south to north on the east side.

The northern limit of the breeding range of *Branta canadensis interior* west of Hudson Bay coincides roughly with the northern limit of trees as delineated by the distribution of black spruce and white spruce, fig. 8. Taverner & Sutton (1934) found that at Churchill, Manitoba, which is "precisely at the limit of tree growth, where the spruce forest dies out on the

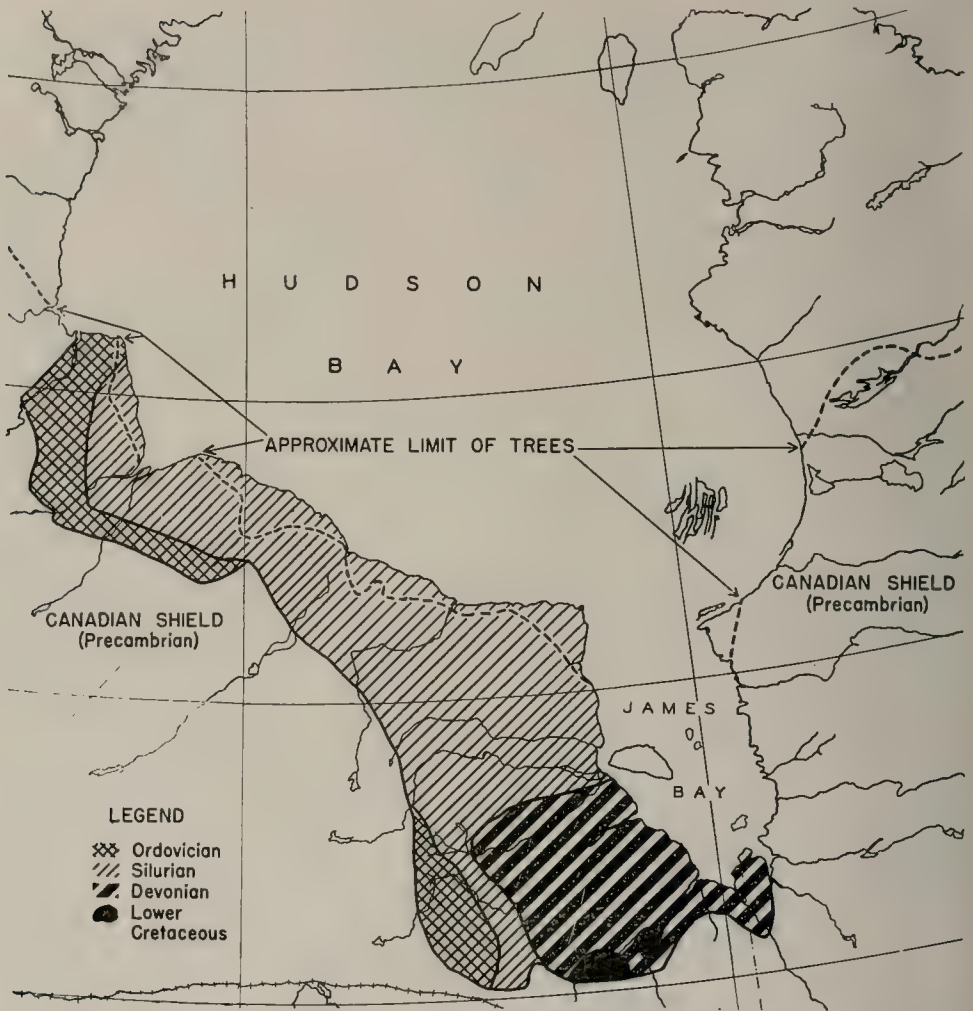


Fig. 8.—Map showing subsurface geological structures south and west of Hudson and James bays. Approximate limit of trees from official Canadian map. The principal nesting range of the Mississippi Valley Canada goose population lies within the shaded area.

arctic tundra and both types of biological association are in contact," the goose they referred to as *Branta canadensis canadensis* "is a common transient, which breeds sparingly in the vicinity."

Preble (1902) recorded that when he was in the region west of James Bay and Hudson Bay considerable numbers of *Branta canadensis* were reported as nesting on an island in Lake Winnipeg. He saw or had reliable reports of young geese along the Fox, the Churchill, and other rivers of the region.

Bell (1880) stated that *Anser cana-*

densis "breeds in considerable numbers along the Churchill River."

Grinnell & Palmer (1941) reported that "birds [*Branta canadensis*] were seen and heard at intervals from June 6 on" in the vicinity of Churchill.

Allen (1945) recorded nests and nesting pairs of *Branta canadensis* near Churchill.

Traverer (1931) wrote: "... it [*Branta canadensis canadensis*] is the common breeding goose of James and Hudson bays for most of the east coast and the west side at least as far as

Churchill, probably stopping somewhere south of cape Eskimo where it appears to be replaced by *leucopareia*." From the barren grounds north of Churchill, the lesser Canada goose, *Branta leucopareia leucopareia* is the common representative of the genus *Branta*.*

Hørring (1937) examined parts of 10 individuals, mainly from Baker Lake, a locality 385 miles nearly due north of Churchill, which he assigned to the race *leucopareia*.

A female goose taken May 20, 1937, at Eskimo Point, on the coast of Hudson Bay north of Churchill, appeared to Shortt & Peters (1942) "to be of the form *leucopareia*."

Specimens taken along the Thelon River, which is in the districts of Mackenzie and Keewatin, Northwest Territories, were "referred by P. A. Taverner to *B. c. leucopareia*" (Clarke 1940).

There are numerous references in the literature regarding the occurrence of the Canada goose south of Hudson Bay and west of James Bay. Richardson (1851) quoted a report of George Barnston, an officer of the Hudson's Bay Company at "Martin's Falls," a post on the Albany River 200 miles inland from James Bay, in which mention is made of "geese and ducks hatching" in the vicinity.

Bell (1887), describing his exploration of the Attawapiskat River, wrote: "The Canada goose breeds in considerable numbers in the open swamps behind the wooded borders of the lower section of the river, and the young birds, ready to fly, were congregating in flocks, all along the lower stretch, in the end of August and the beginning of September."

Baillie & Harrington (1937) wrote: "The Canada Goose breeds fairly commonly along the coasts of James and Hudson bays, between Moose river and Churchill."

South of James Bay the principal breeding range of the Canada goose may not extend more than 60 miles inland from the coast. In 1926, a mining party led by B. C. Lamble explored the country between Timmins, Ontario, and James Bay. During the trip they "saw many broods of Canada geese, but none farther

south than Kesagami Lake, Latitude 50° 30' " (letter to Jack Miner from B. C. Lamble, August 5, 1926).

In regard to the status in other parts of Ontario of the bird they regarded as *Branta canadensis canadensis*, Baillie & Harrington (1937) stated: "Recent maps indicate, perhaps correctly, that this bird may breed in the whole of northern Ontario, north of Lake Superior and the southern end of James Bay."

"The several instances of this bird nesting in southern and central Ontario almost undoubtedly concern injured or semi-domesticated individuals."

Bell (1883), who was undoubtedly intimately familiar with most of the province of Ontario, stated that "between the great lakes and James' Bay, only chance pairs lag behind in their northward flight to hatch their broods."

Inland from many parts of the east coast of Hudson and James bays, and on the islands along the coast and to the north, suitable habitat for nesting Canada geese is less extensive than inland from the west coast. Consequently, nesting on the east side of the bays is relatively concentrated although, in the interior of northern Quebec (Ungava), more widely scattered nesting is found.

The late James Watt, former manager of the Hudson's Bay Company post at Rupert House, wrote the junior author (letter of December 25, 1943) that "While travelling in the interior [south and east of James Bay] surveying beaver lands and counting lodges I have seen as many as 15 to 20 nesting [Canada] geese in a day's travel—all with broods of young geese, and . . . taking into consideration the immense territory and number of lakes and inland waterways, the number of geese that nest inland must be large."

A. P. Low (1896) wrote: The Canada goose "breeds in marshes throughout the northern interior [of Quebec], and is seen along the rivers with young broods about July 1st; . . . several large broods seen on Burnt Lakes, Romaine River; not common at Lake Mistassini, but abundant on East Main River—especially on lower part, where the river is cut out of clays, with good bottomlands; breeds in large numbers on the islands of James Bay."

* See Appendix B for discussion of recent revision by Hellmayr & Conover (1948).

In reply to the questionnaire sent out in 1947, Roy Jefferies, Post Manager at Eastmain for the Hudson's Bay Company, in collaboration with an Indian, stated that Canada geese nested in a swamp about 10 miles south of Eastmain.

It is common knowledge in the James Bay area that considerable concentrations of nesting geese are found on the Twin Islands in James Bay, particularly the South Twin, and on the Belcher Islands in Hudson Bay, fig. 2. Nesting pairs are also found on Charlton Island and a number of smaller islands along the east coast of James Bay.

In the summer of 1947, Donald F. Coates and Donald B. Coombs (personal communication), observers for the Geodetic Service of Canada, visited the following islands in James Bay: North Bear, Bear, South Bear, Bare, Grey Goose, Walter, North Twin, Weston, and Charlton. They found Canada geese on only three of these islands. On Grey Goose, their guide shot two geese but they found little evidence of breeding pairs; on Weston, they saw about 20 pairs, in one instance 6 adults and 21 goslings together on one pond; and on Salt Lake, at the northern tip of Charlton, they observed 1 pair and 6 goslings.

Bell (1883) found that Canada geese "breed on the islands along the east coast of Hudson's Bay . . . it is said that very few Canada geese breed northward of Hudson's Strait."

Manning (1946) mentioned "a considerable number of geese in the Mistake Bay area at the end of July." (Mistake Bay is between Povungnituk and Port Harrison, fig. 2.) He "saw 10 or 15 of them, and all belonged to the large form." He identified them as *Branta canadensis interior*.

In a recent letter (to the senior author, April 11, 1947), T. H. Manning states that he believes the chief breeding ground of Canada geese in this area is between Cape Dufferin (near Port Harrison) and the Cape Smith Range. "I do not . . . think that they often nest on the coastal islands. They may nest on the King George and Sleeper Islands, but the Ottawa Islands are high, rocky and barren, and unsuitable. I have no direct evi-

dence, but I should think they nest throughout the interior between Hudson and Ungava bays."

The Reverend H. S. Shepherd, missionary at Port Harrison, Quebec, for 2 years, stated in the questionnaire sent out in 1947 that scattered nesting of Canada geese is found over a large area of the interior inland from Port Harrison, but that the total number is not great.

Low (1902) found that, in the country about 12 miles south of the Digges Islands,* "The many small ponds and swamps that occur between the boulder ridges are favorite breeding places for grey geese." Farther south, about 30 miles north of the Povungnituk River, Low also found large numbers of Canada geese about 10 miles inland from the mouth of the Sorehead River.

In the Povungnituk area, W. A. Tolboom, a post manager, reported by questionnaire in 1947 that nesting is well scattered over a wide area and that generally speaking all nests are found on islands, on lakes or shores of lakes, seldom on rivers, and very seldom on coastal islands.

Manning's surmise regarding goose nesting over the Ungava Peninsula is substantiated by Rousseau's (1948) finding that the Canada goose is one of the few prevalent forms of wildlife between Povungnituk and Payne Bay post on Ungava Bay.

A few individuals of the Canada goose nest on the arctic islands north of the Canadian mainland. Sutton (1932) reported that Eskimos have occasionally found nests of *Branta canadensis canadensis* on Southampton Island.

Shortt & Peters (1942) reported an immature "specimen referable to *B. canadensis canadensis*" taken August 17, 1938, at Lake Harbour, southern Baffin Island.

Soper (1946) reported that *Branta canadensis canadensis* breeds on Baffin Island along the southern coast of Foxe Peninsula, and from at least Amadjuak Bay to Gabriel Strait along the coast of Hudson Strait.

Mississippi Valley Population.—The limits of the breeding range of each

* Small islands lying off the extreme tip of Ungava, northern Quebec.

of the four populations of *Branta canadensis interior* around Hudson and James bays have been deduced from band recoveries, coupled with a knowledge of the suitable nesting country, figs. 6 and 7. In ascertaining the true distribution of each of these populations, we were fortunate that the Miner banding records, as well as the Horseshoe Lake records, could be analyzed. An interpretation of either the Horseshoe Lake records or the Miner records alone would undoubtedly have led to erroneous conclusions, whereas the two sets of data considered together supplemented each other.

Band-recovery data from the Hudson-James bay area are in large measure de-

pendent upon the native Indians. When interviewed through interpreters, the Indians are usually able to furnish the exact date and place of each band recovery. However, if only the name of the post is known at which a band is secured, the location of the recovery can be approximated, as usually the native groups from the various fur trade posts, including even individual families, use the same hunting grounds year after year. The approximate boundaries of the hunting grounds of the various bands of Indians on the west and south coasts of James Bay is shown in fig. 9, which is copied from a portion of a map prepared by the Reverend John M. Cooper to ac-

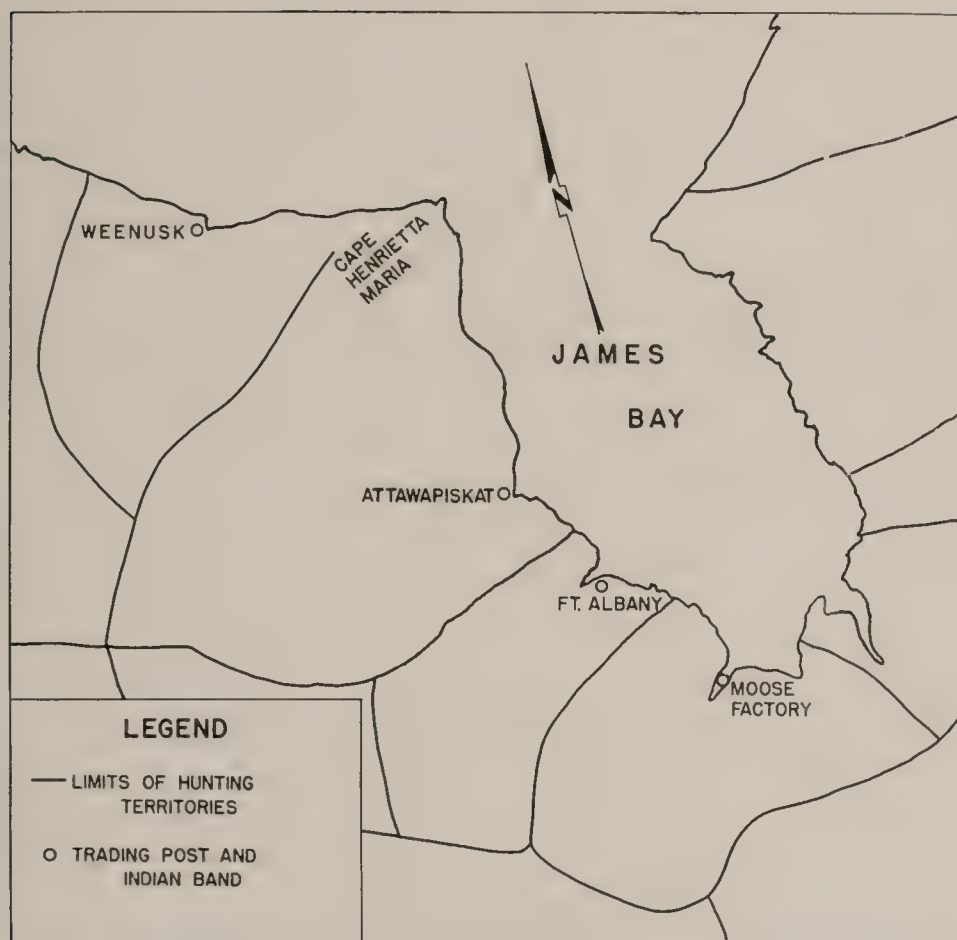


Fig. 9.—Map showing limits of the trapping and hunting grounds of the various bands of Cree Indians west and south of Hudson and James bays. (After Cooper 1933.)

Table 3.—Canadian breeding grounds of the Mississippi Valley Canada goose population, as indicated by spring and summer band recoveries from the Horseshoe Lake flock, 1941-1947.

RIVER OR ISLAND	UNKNOWN EXCEPT BY POST OR RIVER	NUMBER OF RECOVERIES AND APPROXIMATE POINT OF RECOVERY											TOTAL	
		Number of Miles Inland by River From Coast of Hudson or James Bay*												
		0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109		150
Severn River.....	13	3					1			1				18
Winisk River.....	5	4	1				1		2				12	25
Sutton River.....		2												2
Kinusheo River.....	2													2
Lake River.....	32													32
Nowashe Creek.....	3			1										4
Swan River.....	5													5
Neatalkau River.....								3						3
Ekwan River.....					5	1		1	1			1		8
Attawapiskat River.....	16	2	3		2	3	1	1		3				31
Akimiski Island.....	4													4
Kapiskau River.....									1					4
Albany River.....	1	12			6	8	14	6	1	1				50
Stooping River.....	1								1					2
Kinoje River.....	5													5
Nettichi River.....	2													4
Lawapiskau River.....	1													1
Total.....	90	25	4	2	8	16	24	7	6	2	3	1	12	200

*Nearly all distances given by the Indians were in multiples of 10. Most of the band recoveries were from the 30-59-mile zone inland from the coast.

company his unpublished report to the Indian Affairs Branch in Ottawa. Father Cooper's map is based on his field studies of 1927, 1932, and 1933 in the vicinity of James Bay.

According to Father Cooper, the boundary lines of hunting territories generally are represented by natural landmarks, such as heights of land, chains of lakes, or watersheds. Hunting rights to each foot of land are owned by some Indian and are acquired only through inheritance or donation. Territory is generally inherited in the male line and most family territories have been in the same family line for generations. As to the accuracy of these boundaries, Father Cooper writes: "These limits are and can be only approximate as we have not adequate and detailed maps based on surveys of the whole area. . . . The Moose Indian grounds and to a certain extent the Rupert House grounds are plotted as of a generation ago. Some changes through inheritance and through the dying out of certain families, particularly around Lake Kesagami,* have occurred, but in the main the present Indian families still hunt each where the father and grandfathers hunted."

Band recoveries from the Canadian breeding grounds of geese banded at Horseshoe Lake are summarized in table 3. These recoveries, important in revealing the location and extent of the breeding range of most of the Mississippi Valley geese, do not, however, take into account geese that nest in the United States, where several efforts to establish breeding flocks on federal, state, and private refuges are making increasingly important contributions to the Mississippi Valley population.

Most of the Horseshoe Lake bands recovered in Canada were taken in the muskeg country lying inland from the coasts of James and Hudson bays between the Kinoje* and Severn River watersheds, fig. 30. Band recoveries indicate that during the breeding season this enormous section of muskeg country, roughly triangular in outline, contains the bulk of the geese that winter in southern Ontario, Michigan, Wisconsin, Indiana, Illinois,

eastern portions of Minnesota, Iowa, Missouri, Arkansas, Louisiana (Delta), western Kentucky, western Tennessee, and western Mississippi. The barren grounds of Cape Henrietta Maria and the coastal marshes probably do not contain breeding birds, but nesting occurs on Akimiski Island, figs. 2 and 30, which lies in James Bay a few miles east of the mouth of the Attawapiskat River.

Of the tremendous area of muskeg outlined above, only a relatively small portion is either suitable for, or attractive to, nesting geese. Field observations, as well as band recoveries, indicate that the main breeding range of *Branta canadensis interior* south of Hudson Bay and west of James Bay is within an enormous area of muskeg, the limits of which coincide roughly with the area underlaid with sedimentary rocks of the Paleozoic era, fig. 8. These rocks, of the Ordovician, Silurian, and Devonian periods, are covered by a mantle of glacial drift over which the flat muskeg is superimposed. According to Bell (1887), "The drift (principally boulder-clay) which over-spreads the palaeozoic basin westward of James' Bay appears to be a continuous sheet varying probably between thirty and ninety feet as far as can be judged by the sections along the rivers."

Ells (1912) believes that fairly uniform timber and land conditions prevail concentrically from James Bay except for minor variations, depending on primary and secondary drainage.

Thus, if we have a 5 ft. muskeg at a distance of thirty miles south of James Bay, I would look for a similar condition East and West along a belt roughly parallel with the shores of the Bay. . . . This assumption I have based on the fundamental principle that the country adjacent to James Bay on the South and West side is gradually being elevated. . . . As we leave the shores of James Bay, the depth of the muskeg should gradually increase. . . . Eight miles to the west of Moose Factory the depth of moss and muck is 2 ft. to 3 ft.; 10 miles further south the depth is 2 ft. to 4 ft.; and 40 miles, $4\frac{1}{2}$ to 5 ft.; at 60-80 miles, $5\frac{1}{2}$ to 6 ft.; and at 90 miles the depth is 6 to 8 feet.

Evidence that the main breeding grounds of the Mississippi Valley Canada

* A small river that flows into James Bay 8 miles south of the Albany River.

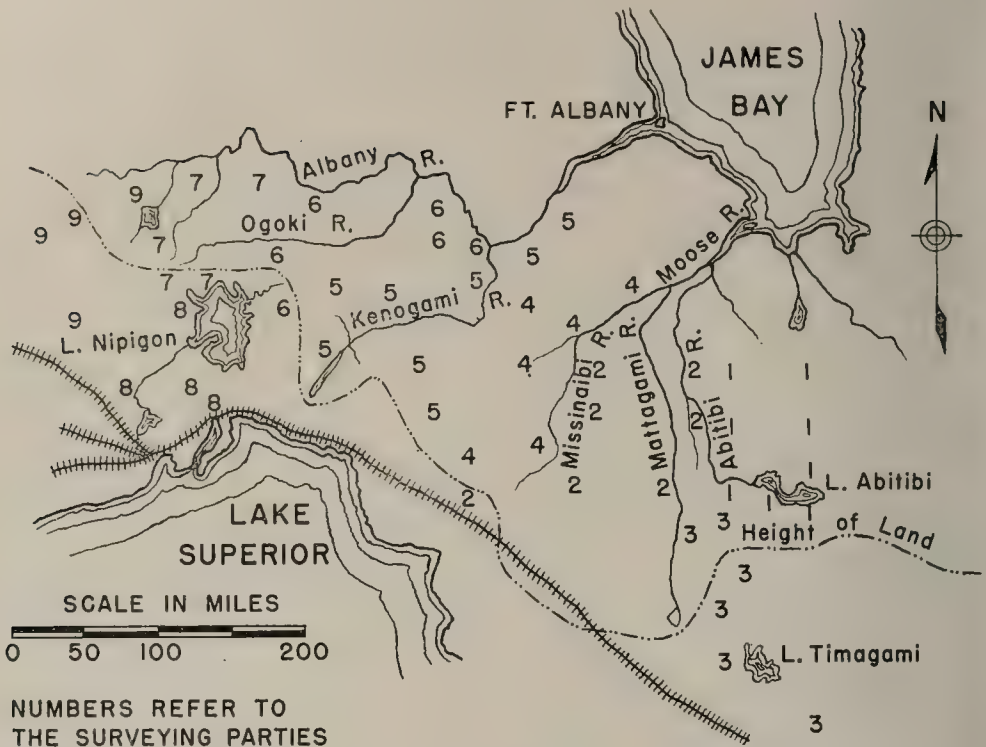


Fig. 10.—Map showing districts explored by surveying parties in northern Ontario in 1900 (from Anonymous 1901). None of the surveying parties reported nesting Canada geese in the districts surveyed.

geese probably do not lie much beyond the coastal strip of country that is underlaid with sedimentary rock, and are not in the adjoining rocky and rugged Canadian shield, is found in the records of 10 surveying parties. In the summer and autumn of 1900, surveys and explorations were made of the natural resources and characteristics of part of northern Ontario by the Ontario Department of Crown Lands (Anonymous 1901). The subject of the survey was a "comparatively unknown part of the District of Nipissing, bounded on the north by the Great Muskeg, adjoining the southern shore of James' Bay." The country, beginning about 80 miles inland from James Bay, was surveyed by districts, an exploring party being assigned to each of 10 districts. The districts that have relation to this study are shown in fig. 10. Each exploring party kept notes on the game conditions in its respective district, and, although a number of kinds of ducks were

reported nesting in several of the districts, no nesting Canada geese were noted.

Observations made by Hess (1943) during a plane flight shed additional light on the occurrence of Canada geese southwest from James Bay. His description of the muskeg in that sector could apply to a large portion of the muskeg over the Paleozoic Basin.

By the time we were in McCausland Township, the country had changed from the poplar and jackpine regeneration on the slopes around the Mattagami River to a vast flat area of muskeg, exactly similar to the country around James Bay. (At this point, we were about 100 miles from the Bay.) Throughout this area, except for a belt of fair-sized spruce along the rivers and larger streams and the bigger lakes, there was no tree growth except dwarf widely-spaced tamaracks and the odd bunch of black spruce trees. The remainder of the area was a greyish yellowish green blanket of moss interspersed in large patches by ripple-like depressions filled with water,

giving a striking similarity to waves of moss and water.

Hess observed only four geese in the area described above. After flying a considerable, but unstated, distance farther, he sighted a chain of five lakes, on one of which were two flocks of geese; "young appeared to be present." Hess reported these lakes as being shallow.

The shores to about 100 feet from the water are ringed by black spruce trees about 30 feet high which shade off a short distance from the lake into the muskeg. The immediate shore was covered by alder and

willow and in the far distance the larger spruce trees along the Missinaibi River stood out sharply above the scrub larch and muskeg.

Other Populations.—From the 5,747 Canada geese banded at Horseshoe Lake, only 4 bands have been recovered from the country adjacent to Hudson Bay northwest of Fort Severn, fig. 30. Two of these bands were from geese killed in early spring south of York Factory, apparently in the vicinity of their breeding grounds. Of the more than 16,000 Canada geese banded at the Miner Sanctuary in the autumn, none has been re-

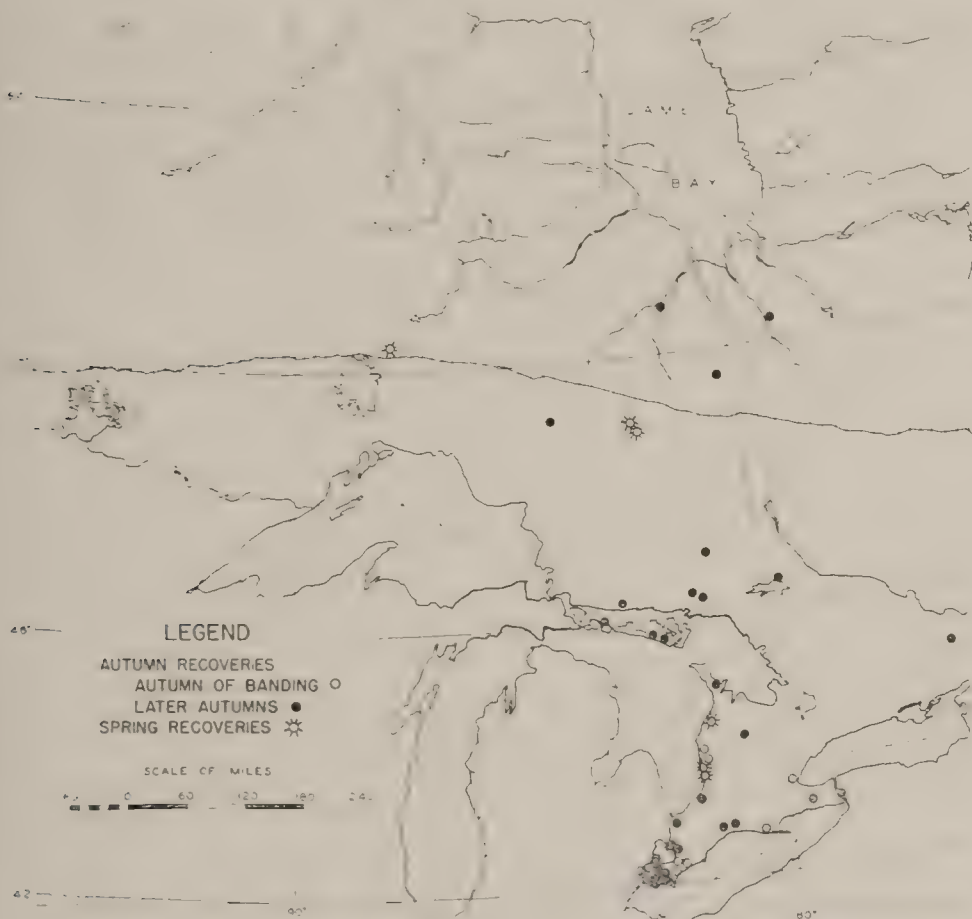


Fig. 11.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary in the autumn, 1915–1944, and reported recovered south of James Bay in Canada. Recoveries reported from fur-trade posts on the coasts of Hudson and James bays are indicated in fig. 7. Banding records indicate that two Canada goose populations, the Mississippi Valley and the Southeast, stop at the Miner Sanctuary in the autumn.

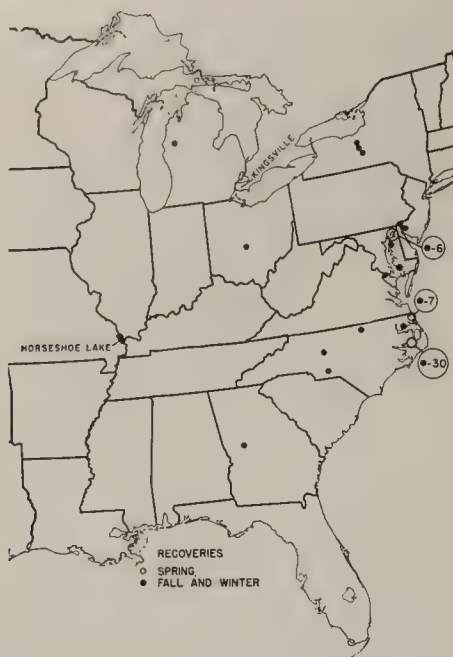


Fig. 12.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary, Kingsville, Ontario, in the spring of years prior to 1934 and reported recovered in the United States in the autumn and winter of 1935-36 and (one from a goose found dead) in the spring of 1936.

ported shot north of Lake River, figs. 2 and 7. Hence, it seems probable that most of the muskeg country between Fort Severn and Churchill is occupied by a population of geese that by-pass both the Miner and Horseshoe Lake refuges on their migration to wintering quarters. Miner bands recovered in Canada south of James Bay are indicated in fig. 11. Since few geese banded either at Horseshoe Lake or the Miner Sanctuary have been reported from western Louisiana and eastern Texas, or from any point at an appreciable distance west of the Mississippi River, figs. 12-21, it appears that the western Louisiana flocks, and perhaps a few concentrations in central Missouri, are derived from the breeding grounds between Fort Severn and Churchill. (Fig. 12 shows recoveries of geese banded in the spring; figs. 13-21 show recoveries of geese banded in the fall and winter.) The geese that breed in this part of Canada should probably be included with

the Eastern Prairie population, as recently proposed by Cecil S. Williams of the United States Fish and Wildlife Service.

It is apparent from the distribution of the band recoveries shown in figs. 14-21 that two distinct populations of geese are banded at the Miner Sanctuary in the autumn: one population that migrates southwest to winter in the Mississippi River valley; the other, designated as the Southeast population, fig. 6, that crosses the Appalachian Mountains and winters in the inland areas of the South Atlantic states. From the data at hand we can only speculate on the approximate line of demarcation between these two populations on the breeding grounds. Although band recoveries indicate that the breeding grounds of the Mississippi flyway population extend as far south as the Kinoje River, the mouth of which lies 8 miles south of the mouth of the Albany River, between the Kinoje River and the Moose River country there may be a zone of overlap in which is found a mixed popula-

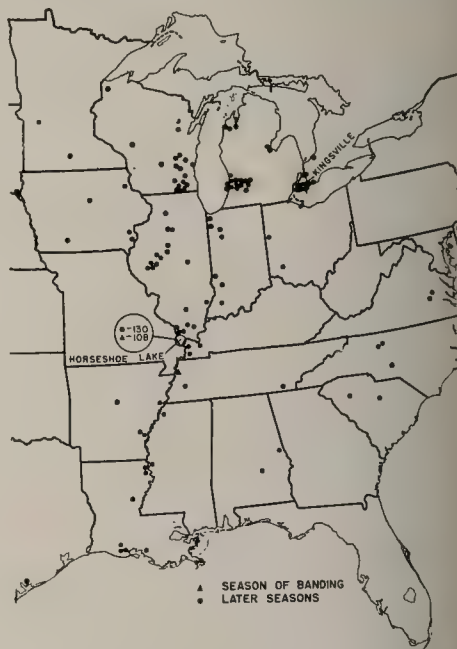


Fig. 13.—Location of band recoveries from Canada geese banded at the Horseshoe Lake Game Refuge and reported recovered in the United States and southern Ontario, 1940-1945. (Missouri recoveries near Horseshoe Lake.)

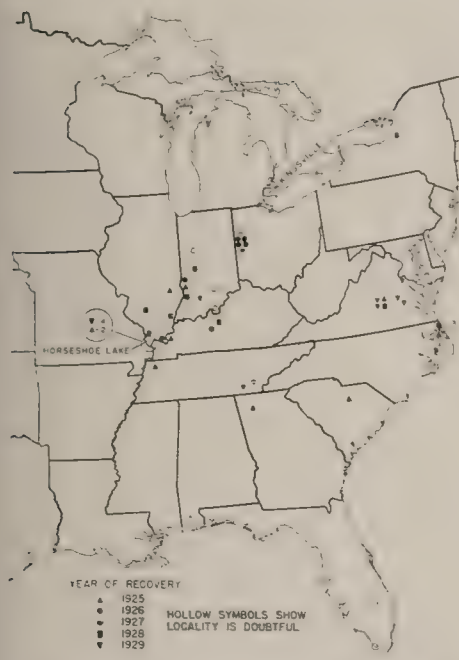


Fig. 14.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1925-1929, and reported recovered in the United States during the season of banding.

tion of geese, some of which winter in the Mississippi River valley and others that winter in the inland portions of the South Atlantic states.

The principal breeding range of the Southeast population lies inland from the south coast of James Bay. The data available at present suggest that it includes areas drained by the Moose River, as well as suitable muskeg lying between the Moose and Nottaway rivers, and perhaps areas lying inland from the east coast for an indeterminate distance north, fig. 6. Banding records from the Miner Sanctuary show that many of the autumn-banded geese are taken in the spring in the country around the south end of James Bay, fig. 7, and many are taken in the autumn in the inland portions of Virginia, North Carolina, South Carolina, Georgia, Alabama, and the Gulf Coast of Florida, figs. 14-21 (also see Appendix A).

Recoveries from geese banded at the Miner Sanctuary in the spring clearly

indicate that the breeding grounds of the flocks that winter along the Atlantic Coast from Maryland to North Carolina, fig. 12, include certain islands in James and Hudson bays (see pages 81-82) and areas inland from the east coast of these bays from about Rupert House to southern Baffin Island, fig. 7.

The large number of band recoveries from the Port Harrison region on the east coast of Hudson Bay, despite low nesting densities reported for that area, may be due in part to the influx of geese in late summer into this lake country, which lies north of the tree line. According to the Reverend H. S. Shepherd, large numbers of Canada geese fly in from the north to the barren-ground lakes for the purpose of moulting. Band recoveries suggest that there may also be an influx of geese that have flown in from considerably south of Port Harrison. No confirmation of this influx was received in the questionnaire distributed in the region; however, A. Lunan of the Hudson's



Fig. 15.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1930-1934, and reported recovered in the United States during the season of banding.

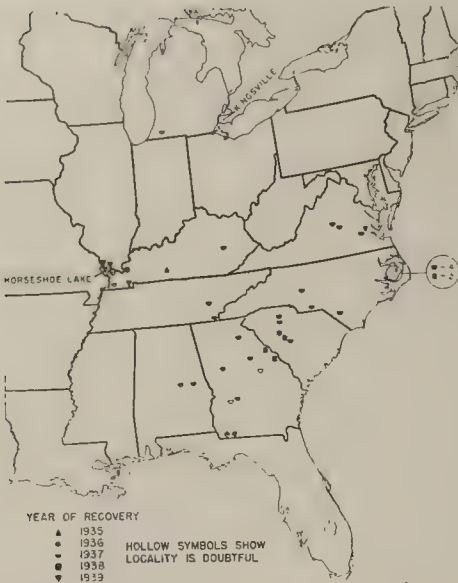


Fig. 16.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1935-1939, and reported recovered in the United States during the season of banding.

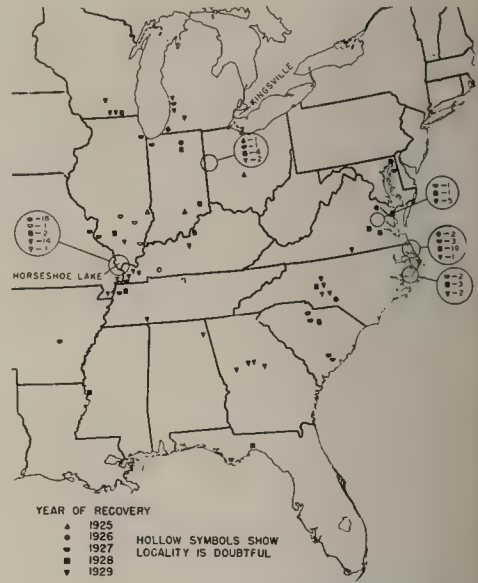


Fig. 18.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1924 or before, and reported recovered in the United States during 1925-1929.



Fig. 17.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1940-1944, and reported recovered in the United States during the season of banding.

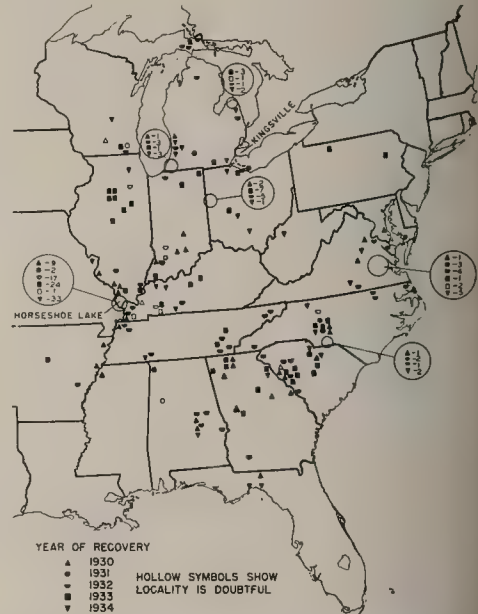


Fig. 19.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1929 or before, and reported recovered in the United States during 1930-1934.

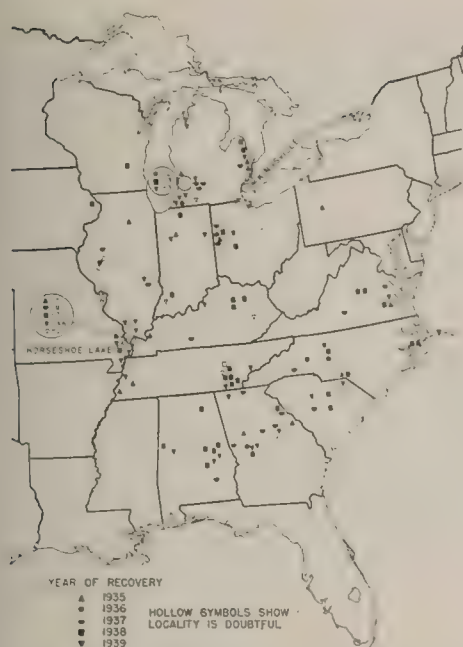


Fig. 20.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1934 or before, and reported recovered in the United States during 1935-1939.

Bay Company, who was stationed a number of years at Port Harrison, recently stated (personal conversation, August, 1949) that about 75 per cent of the geese killed by the Eskimos in that area were moulting geese that came into the area in early June from the south and not birds that nested locally. His observations thus help to substantiate a relationship that could only be surmised from band recoveries. The Eskimos in the vicinity of Port Harrison, finding other kinds of game less easily obtainable in summer, turn to the inland lakes, where apparently they secure a plentiful supply of flightless geese.

Sixteen recoveries of Canada geese banded at Horseshoe Lake, fig. 30, and an important percentage of the total recoveries of geese banded at the Miner Sanctuary in the autumn, fig. 7, have been made in the Port Harrison district. One or more of a number of possibilities may explain these inconsistencies in the recovery pattern: flights by small groups of Mississippi flyway geese across James and Hudson bays in late summer; north-

ward movements by geese of the Southeast population along the east coast of the bays for the purpose of feeding on berries; actual intermingling of birds from the different flyways. Trapping at the Miner Sanctuary has shown that some of the Horseshoe Lake geese stop at the Sanctuary in the spring, along with the flight of South Atlantic geese. Of 33 Canada geese trapped and banded at Horseshoe Lake and retrapped at the Miner Sanctuary, 1943-1945, 11 were retrapped in the spring. The disposition of some Horseshoe Lake geese to follow the South Atlantic geese to the east coast of Hudson Bay would not be surprising. Recovery of F-marked (autumn banded) birds in the Port Harrison district might be partially explained by the banding of South Atlantic geese at the Miner Sanctuary in the autumn. A certain amount of overlap in migration routes, with the resultant intermixing at the Miner Sanctuary of South Atlantic geese with Southeast and Mississippi flyway birds, is no less to be



Fig. 21.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1939 or before, and reported recovered in the United States during 1940-1944.

expected in the autumn than in the spring of the year.

West Coast Muskeg Types

Aerial reconnaissance flights in the region west of James Bay and south of Hudson Bay, fig. 4, revealed that the muskeg in the breeding range of Mississippi Valley Canada geese differs considerably in various sectors in the proportions of timber and water it supports. For the sake of convenience the muskeg can be divided into five main types. It must be remembered, however, that gradations between all types exist.

Type 1. Well-timbered muskeg, with only a few ponds or small, widely scattered lakes, fig. 22.

Type 2. Open muskeg, with treeless or lightly timbered areas of stunted tamarack, alternating with small blocks or extensive stands of black spruce, fig. 23.

Type 3. Lake-land muskeg, relatively

well-drained areas, more or less timbered, but notable for the numbers of large, widely scattered lakes without islands, fig. 24.

Type 4. Pothole muskeg, characterized by a myriad of ponds and small lakes, principally from 5 to 30 acres in size and usually possessing one or more islands. These water areas are often so closely grouped that only small patches or narrow strips of land separate one from the other, figs. 25 and 26.

Type 5. "Smallpox" muskeg, that is, muskeg in which sphagnum predominates, the country being more or less a continuous sphagnum bog or series of small bogs in the late stages of filling in so that it can scarcely be classified as land or water, figs. 27 and 28. Fairly extensive areas of this kind occur throughout the Paleozoic Basin and in smaller patches within most areas of the above four types of muskeg.

Aerial observations revealed that the



Fig. 22.—Type 1 or well-timbered muskeg. The muskeg lying adjacent to the southern half of the west coast of James Bay is fairly well wooded with black spruce and tamarack. Alternating with the wooded tracts are extensive areas covered with a heavy growth of willow. Ponds and lakes are relatively few in number in this area.



Fig. 23.—Type 2 or open muskeg. The dark bands across the lower half of this illustration represent stands of black spruce; the lighter colored trees are tamaracks. The spruces are confined mainly to better drained sites and to hummocks of mosses and lichens. The tamarack occurs both as light stands on the better drained sites and as scattered, stunted individuals on open sedge areas. In this type of muskeg, the treeless or lightly timbered areas of stunted tamarack alternate with small blocks or extensive stands of black spruce.

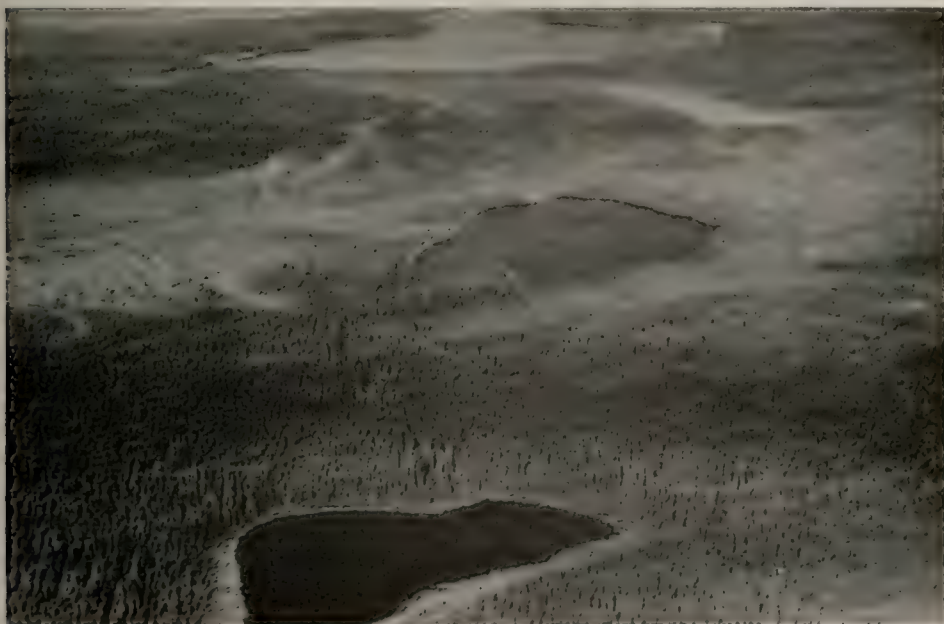


Fig. 24.—Type 3 or lake-land muskeg. Shown here is an area just north of the Albany River (flight I, fig. 4) about 45 miles inland from the coast of James Bay.



Fig. 25.—Type 4 or pothole muskeg. This photograph was taken a few miles north of the Albany River on flight IV, fig. 4.



Fig. 26.—Type 4 or pothole muskeg about 40 miles north of the Moose River and about 30 miles inland from the shore of James Bay.

muskeg for the first 20 to 25 miles inland from the coast of James Bay in the Albany River country, fig. 4, I and III, exclusive of coastal marshes, is chiefly type 1. The muskeg for the next 35 to 40 miles, or about to the longitude of Fishing Creek Island in the Albany River, is characteristically type 4. Most prevalent in the country between Ogoki and points 50 to 60 miles inland from James Bay, fig. 4, I, are types 2 and 3. From Ogoki, on the Albany River, to a point northwest on the Attawapiskat River, fig. 4, II, muskeg types 2 and 3 characterize the country. From this point on the Attawapiskat River to Fort Albany, fig. 4, III, the kinds and the distribution of the muskeg observed are similar, but in reverse sequence to those seen on flight I, fig. 4.

On flight IV, fig. 4, between the Albany River and Weenusk, the following sequence of muskeg types was found to prevail. Type 4 is dominant between the Albany River and the Atikameg

River, which lies 15 to 30 miles north of the Albany; types 2 and 3 most of the way between the Atikameg and Kapiskau rivers, north to the Attawapiskat River, and for an additional 10 to 15 miles beyond. Midway between the Attawapiskat and Ekwan rivers the muskeg varies between types 4 and 5. Near the Ekwan River, the country appears to be better drained and timbered, and the muskeg of type 1. From the Ekwan River northward, muskeg types 2 and 3 again prevail, but near the Sutton River, which enters Hudson Bay from the southwest at a point 64 miles west of Cape Henrietta Maria, the muskeg is poorly drained and well supplied with lakes of all sizes. From the Sutton River country to Weenusk the density of the stands of black spruce decreases and the amount of *Cladonia* lichen as ground cover steadily increases; in other respects the muskeg observed in this part of the flight seems to be either type 3 or type 5.



Fig. 27.—Type 5 or "smallpox" muskeg, about 15 miles north of the Attawapiskat River (flight IV, fig. 4).

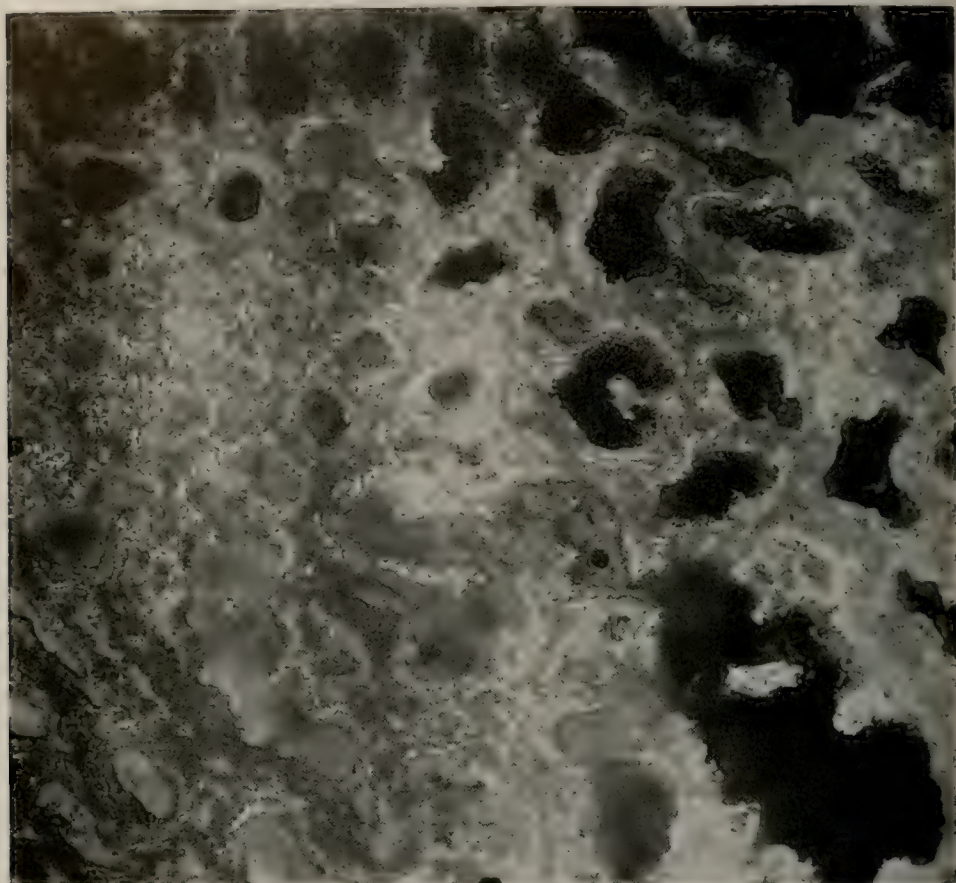


Fig. 28.—Type 5 or "smallpox" muskeg, a vertical aerial view. Small bogs, such as these, in various stages of filling in with sphagnum moss, occupy considerable areas of the muskeg country west of James Bay. They contribute little or nothing to waterfowl production.

Between Weenusk and Fort Severn, fig. 4, VIII, muskeg types 4 and 5 are most common. However, the lakes in this section of the muskeg, some of which are large, do not appear to offer optimum habitat for nesting pairs of geese, as most of them lack islands. The country between Fort Severn and York Factory, fig. 4, VII, appears to be on the whole relatively poor breeding range. In general, the muskeg alternates chiefly between types 3, 4, and 5.

West Coast Production Centers

On the aerial flights outlined in fig. 4, approximately 217 Canada geese, adults and goslings combined, were observed. From these sight observations, from band

recovery data given in table 3, the distribution of the various muskeg types, their relation to the configuration of the streams and rivers, and the literature, the existence and location of major production centers, rather than continuous nesting areas, have been deduced. Most of these areas are between two adjacent or converging rivers, similar to the river shown in fig. 29, but in type 4 muskeg.

Most band recoveries and sight observations of geese can be correlated with the distribution of pothole muskeg, type 4. In the majority of areas in which geese were observed, water areas occupied at least 25 per cent of the surface. This muskeg type occupies slight but extensive depressions or troughs in the Paleozoic

Basin, which probably either (1) originated as depressions in the surface of the glacial drift that mantles the region or (2) developed in connection with deposits accumulated during the uplift of the region, probably at an irregular rate, following its submergence during glaciation. These basins now serve as origins of many small streams, while the larger rivers, in seeking the lowest ground when cutting their channels, have tended to converge toward each other in the region of these basins. Consequently, the present-day configuration of the drainage pattern is a clue to the location of pothole muskeg and in turn of production centers for Canada geese.

Available information indicates the following production centers, fig. 30, for the Canada geese that use the Mississippi flyway:

Production Center A. Between the Albany and Attawapiskat rivers in the region of Ogoki and Martin Fall, about 200 miles from the coast of James Bay. Barnston's early report (Richardson 1851) and band recoveries point to the presence of this production center, although it

seems to be a relatively unimportant one. The localities mentioned above are just within the western limits of the Paleozoic Basin, figs. 2 and 8. In 1947, the 16 hunters in the Ogoki Indian band were questioned regarding the presence of breeding pairs within their trapping territories. Only a few of the hunters had knowledge of Canada geese nesting in the general region north of Ogoki, and they agreed that breeding pairs were scarce in that sector. A single goose was sighted in this area on flight II, fig. 4.

Production Center B. Between the Atikameg and Albany rivers, from a distance of about 25 miles inland from the coast of James Bay westward to about longitude $82^{\circ} 50'$ or the longitude of Fishing Creek Island in the Albany River. Although the country between the Albany River and the Stooping River, a tributary to the south, was not flown over directly, as much of it as could be seen from the plane appeared to be similar to the country between the Albany and the Atikameg and equally attractive to nesting geese; probably it should be included as part of the production center. The area



Fig. 29.—The Attawapiskat River, at a point 30 miles inland from the coast of James Bay. Most of the muskeg shown in this photograph is classified as type 2 or open.

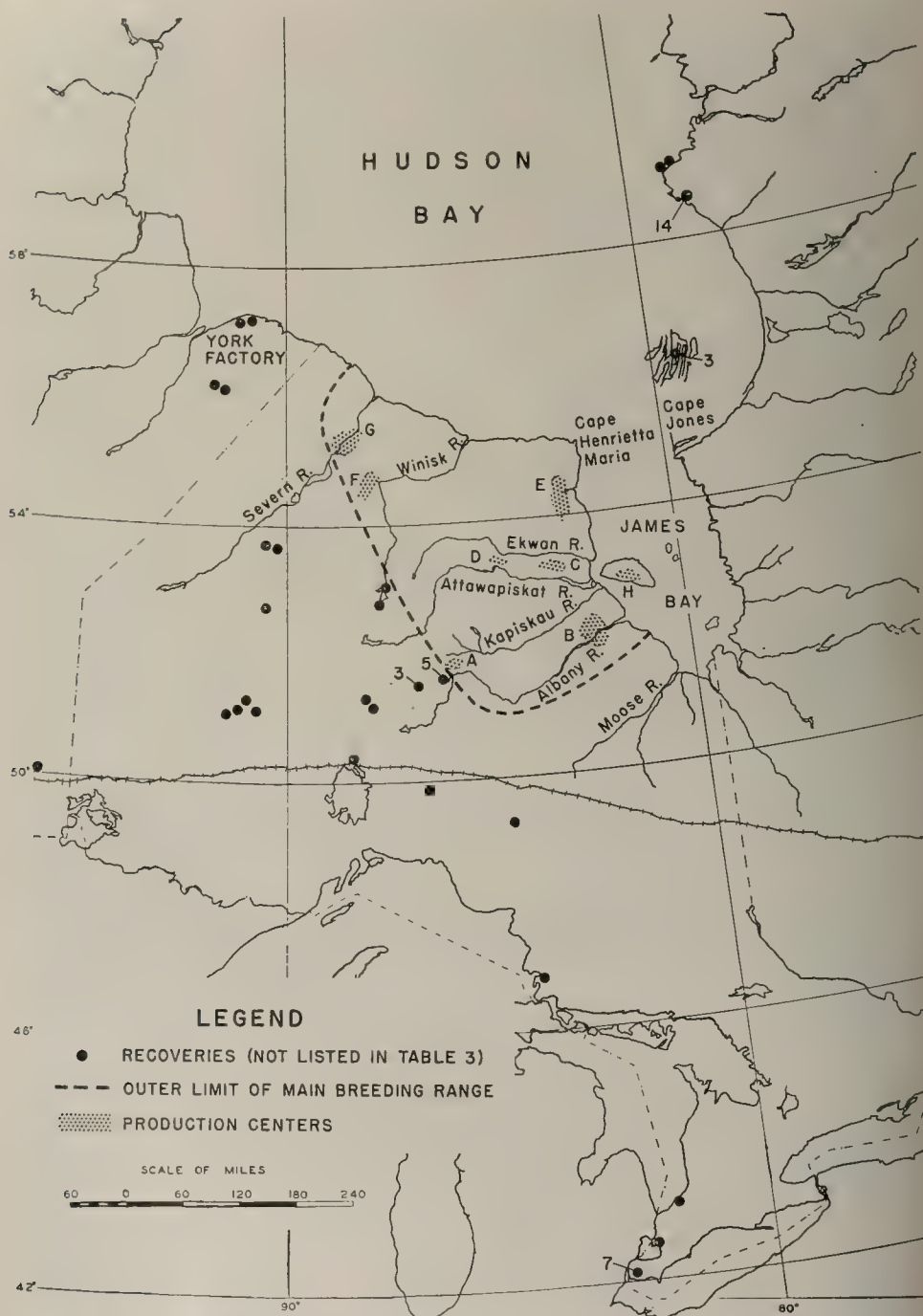


Fig. 30.—Location of production centers, limits of the main range of the Mississippi Valley geese, and located recoveries in Canada, 1941–1947, of Canada geese banded at the Horse-shoe Lake Game Refuge. Within the main breeding range 217 band recoveries have been made. (Not shown are one recovery from Warren, Manitoba, and one from McLean, Saskatchewan.)

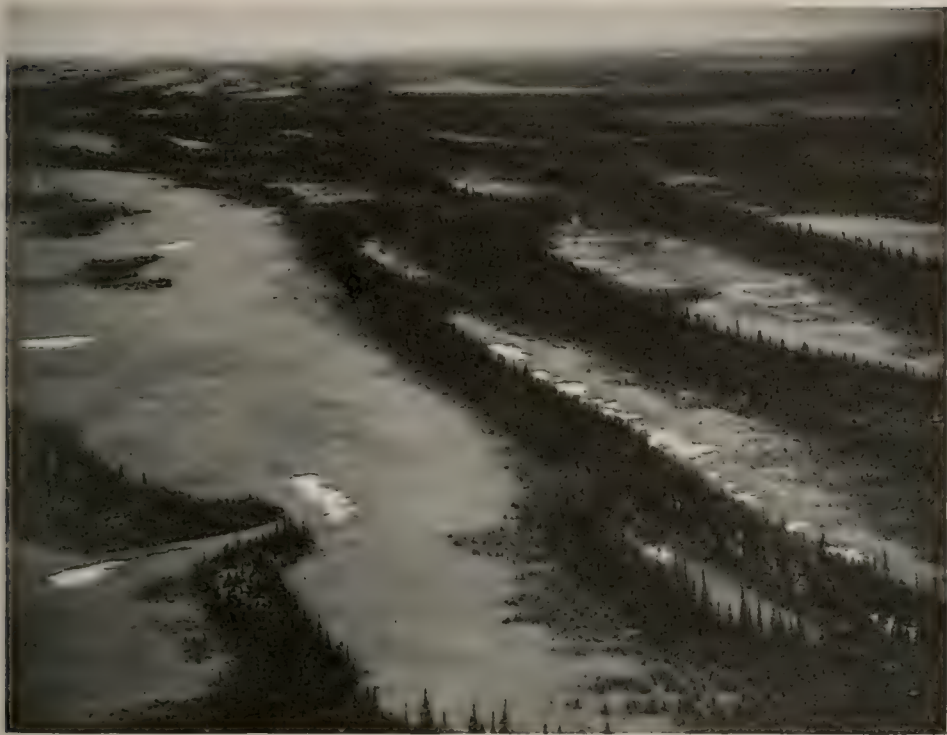


Fig. 31.—View from the west coast of James Bay about 38 miles south of Lake River. The sinuous tracts of spruce occupy old beach ridges near the coast; the intervening areas are marsh. Many bands were recovered from Canada geese near this part of the coast.

observed, which is characteristically type 4 or pothole muskeg, contained the only geese seen on the east and west flights between Fort Albany and Ogoki. On the return flight, III, fig. 4, 55 adults and 19 goslings were observed. These observations substantiate the location of production center *B* up the Albany River, indicated earlier by band recoveries, table 3.

Field observations and information obtained from Indian hunters indicate that few if any geese nest within 10 miles of the shore of James Bay. The Indians report that very few geese breed in the muskeg close to the bay. Most band recoveries, table 3, from the 9-mile coastal zone probably represent migrating geese shot early in the spring, or wandering, nonbreeding geese.

Despite the fact that some of the Indians from the coastal posts trap and hunt far inland, they have made only a few recoveries of goose bands in the Albany

River district more than 60 miles west of James Bay. Substantiating our own finding in the Albany River district, the Indians report that most of the geese breed within 70 miles of the coast, or not much farther west than 30 miles below the juncture of the Albany and Chipie rivers.

Production Center C. Between the Attawapiskat and Ekwan rivers at a distance of between 40 and 50 miles inland from the coast of James Bay. This area was flown over on northward flight IV, fig. 4, from the Albany River to Weenusk. Band recoveries and aerial observations indicate that this area is a relatively unimportant production center. While its extent east and west can only be surmised from band recoveries, aerial observations indicate that its north and south axis is short, approximately 12 miles. Taken as a whole, the potholes and lakes between the Attawapiskat and Ekwan rivers are in a much more ad-

vanced state of filling in than are those between the Atikameg and Stopping rivers and few contain islands. Consequently, they are less attractive to nesting geese. On flight IV, fig. 4, three geese were observed in this production center, and northwest of this center, about 11 miles south of the Sutton River, a single goose was noted.

Production Center D. Between the Attawapiskat and Ekwan rivers, from 90 to 100 miles inland from the coast of James Bay. A production center in this area is suggested by three recoveries, table 3, and some convergence by the two rivers mentioned, as well as by the drainage pattern of the small streams in this area.

Production Center E. South of the barren grounds of Cape Henrietta Maria; from about the latitude of Lake River south to the Swan River and at indeterminate distances inland from the coast of James Bay. The large numbers of recoveries made along the coast in this area, fig. 31, and the multitude of small, short rivers that drain inland areas in this sector suggest that the production center may lie within 15 miles of the James Bay coast. Perhaps indicative of the approximate location of this center is the Kinusho River, which originates in this region and flows to the northwest to empty into Hudson Bay. When the latest 8-miles to 1-inch maps, based upon high altitude photography carried out in 1947, are completed, the limits of this center will be more easily ascertained.

Production Center F. Between the Winisk River and the Fawn River, at a point about 100 miles inland from the coast of Hudson Bay. In this sector the Winisk River and the Fawn River, the latter a tributary of the Severn River, bow sharply toward each other. Between these rivers a dendritic drainage pattern with a number of poorly defined lakes is shown on an 8-miles to 1-inch Canadian topographic map. At Weenusk, where there are some fairly suitable nesting lakes close to the coast of Hudson Bay, the Indians report that they shoot most of their banded geese, table 3, about 150 miles up the Winisk River in the general region outlined above. The winding of this river accounts for the difference in the two mileage figures given for the location of

this production center. Map and band recovery data and the size of the kills made by the Weenusk Indians indicate that this production center is second in importance only to the one between the Atikameg and the Albany or Stopping rivers.

There is probably some scattered nesting over a large area south of Weenusk. On flight IV, fig. 4, two flocks, one of 21 geese and another of 6 with goslings, were sighted about 33 miles south of the Winisk River at a point about 25 miles from the coast of Hudson Bay. On flight VIII, fig. 4, between Fort Severn and Weenusk, 15 Canada geese were observed from the air. However, the lakes flown over on flight VIII did not appear to offer optimum habitat for nesting pairs, as they generally lacked islands. The Weenusk Indians say that they find breeding pairs nesting closer to the coast in early, mild springs than in late, cold springs.

Production Center G. Severn River country. One or perhaps several production centers, poorly defined in either case, may lie in the Severn River country. The configuration of the river and its tributaries and two band recoveries suggest that a production center may be found somewhere between 50 and 90 miles up this river.

William Glennie, a post manager for the Hudson's Bay Company, told the senior author in 1947 that he had seen fresh goose eggs that were taken from nests found in the upper portions of the Severn River watershed, between Windigo and Big Trout Lake, localities that lie just west of the Paleozoic Basin, roughly between latitudes $52^{\circ} 30'$ and 54° , but stated further that the greatest numbers of Canada geese were found along the lower portions of the Severn River.

On flight VII, from York Factory to Fort Severn, a distance of about 145 miles, 28 Canada geese were observed, a number that is indicative of a low population density in this section of the Paleozoic Basin. Observations and aerial photos reveal that the habitat in this area is of relatively poor quality. Many of the water areas are in the late stages of filling in and the great majority of lakes lack islands. Nevertheless, a portion of the muskeg west of Fort Severn probably



Fig. 32.—During the spring and summer the muskeg country is very difficult to traverse on foot. In scene pictured here, small spruce are being put down in order to permit crossing between two mats of floating sedge. The photograph was taken in the Lawapiskau River country on July 3, 1947, at which time ice still could be found in many places 15 inches below the surface of the sedge mat.

should be included in the general breeding range of the Mississippi flyway population because bands have been reported from this country. The breeding density of Canada geese is probably greater than the small number of band recoveries indicate for this section of the muskeg, fig. 30, because of the preference of the Indians at York Factory for hunting other kinds of geese on the coast of Hudson Bay: Richardson's goose (*Branta hutchinsii*) and the lesser snow goose (*Chen h. hyperborea*), species said to be fat both in the spring and in the autumn, while the Canada goose is reported to be thin and unpalatable when it arrives on the interior breeding grounds.

Production Center H. Akimiski Island. From the accounts of the Indians at Attawapiskat and observations made from the

air, nesting on Akimiski Island is found chiefly in the central portion close to the south coast. In this area many suitable lakes were seen and 61 geese were observed on the 1947 flight.

Nest Sites

Although there are a number of fairly well-defined centers of production where most of the geese nest and rear their young, aerial flights in 1947, fig. 4, substantiated the information gathered earlier from the Indians that the breeding pairs are scattered within these centers; there is seldom more than one pair on a given lake. Further evidence pointing to scattered nesting was gained by the senior author in 1947 when traversing the muskeg on foot. A few penetrations of the muskeg were made at points 15 and 25



Fig. 33.—Typical type 4 muskeg lake with small islands. According to native Indians, small islands in lakes of this kind offer preferred nesting sites to Canada geese.



Fig. 34.—Vertical view of type 4 or pothole muskeg. Extending outward from most stands of trees is a floating mat of sedge partially supported by sphagnum moss.

miles up the Lawapiskau River, reportedly goose-nesting country, and at two points 40 miles up the Albany River, which the aerial flights a few days before had revealed as production centers. During these walks, only one pair of geese was observed, but the faint trails of several broods were found, revealing where geese had moved from one small muskeg lake to another.

Unfortunately, because the breeding pairs were scattered and the nesting habitat was highly inaccessible, both from the standpoint of getting a canoe within walking distance of a production center and of actually traversing it on foot, fig. 32, no nests were located in 1947. According to the Indians, small islands in lakes and ponds offer preferred nesting sites, figs. 33 and 34, but, where no islands are present, nearly any location close to the water's edge is suitable. An impression gained from the aerial survey is that small lakes of 5 to 30 acres in size and possessing one or more small islands are the type preferred by nesting pairs.

In the western United States, Canada geese have been found by wildlife workers to concentrate in favored sections of a marsh or breeding range, such as particular islands in lakes and reservoirs. As a result of such colonial-type nesting, young broods of several pairs frequently combine into a large rearing brood, a single pair eventually taking charge of this brood. The fact that only families of normal size have been observed at Horse-shoe Lake, or have been reported by Jack Miner at Kingsville (see section on "Productivity"), suggests that scattered nesting is the rule in the muskeg west of James Bay; the assumption is that nesting pairs are so spaced that contacts between broods are infrequent and combination does not take place to an important degree.

Information corroborating this viewpoint was reported by R. M. Duncan and A. H. Michell. Both of these men have spent many years as post managers on the east and west coasts of James Bay. They report that the autumn migration of Canada geese along the west coast is primarily that of small family flocks, observations which are in agreement with those made by the authors. On the east coast, according to Duncan and Michell,

flocks of from 20 to 40 or more geese generally comprise the autumn flight. However, the presence of large flocks in the autumn along this coast of James Bay is not surprising since areas of favorable habitat are more limited there and the density of nesting pairs is relatively high, particularly on the Belcher and Twin islands. Donald F. Coates and Donald B. Coombs, as cited earlier (personal communication, 1947), found 6 adults and 21 goslings together on Weston Island. From these reports it would seem that in the Hudson and James bay region, as in western United States, crowding of the nesting pairs is a factor likely to induce the combining of broods.

MIGRATION

The beautiful and often spectacular flights of the Canada goose have probably held a greater fascination for more people than the flights of any of our other native birds. Some persons think of geese in flight as special creations, living enviable and unfettered lives. Other persons thrill to the sight of migrating geese as an object of sport. To the Canadian Indian trapping in the "bush," the first flocks of geese in early spring afford a welcome opportunity for a change of diet from bannock, beans, and dried or salted meats. In years when fur and game animals are at low points of their cycles, and consequently food stocks are close to depletion, the arrival of geese may mean relief from near starvation.

Autumn Migration Routes

Our data on the movements of the Canada goose in the Hudson-James bay area are based on information received from the Indians and white residents and on personal observations. Band recoveries have been the principal source of information relating to autumn migration movements of Canada geese in the United States, figs. 13-21, but these recoveries do not furnish a complete picture of the migration routes. Naturally, most recoveries are from localities where hunters as well as geese congregate, generally in the vicinity of favorite waterfowl rest lakes or feeding areas where the flocks linger before continuing south. Wooded

or hilly country and waterless prairies are usually flown over nonstop by migrating geese. Consequently, very few bands have

been recovered from country of this nature, even though large numbers of geese pass overhead each autumn and spring.

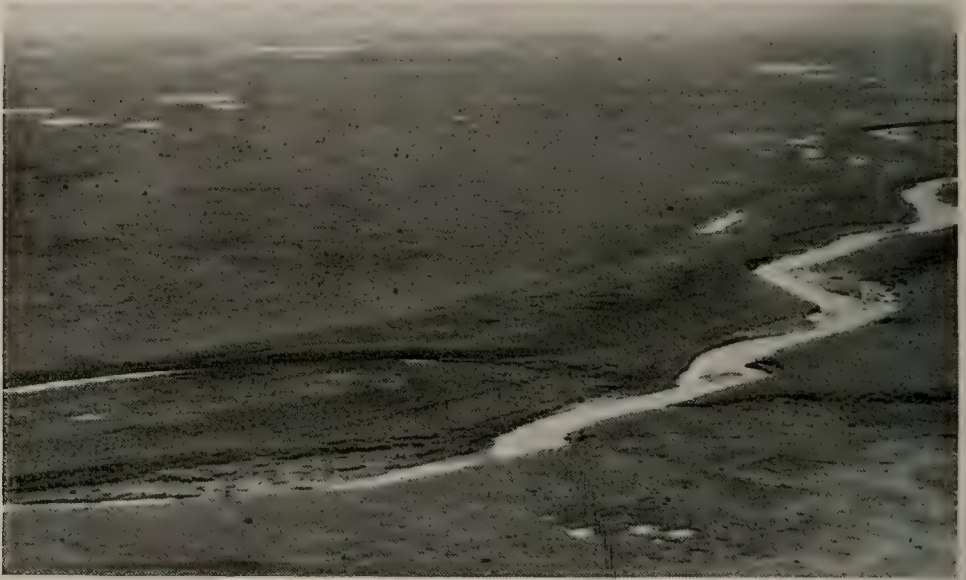


Fig. 35.—The tundra of the Cape Henrietta Maria area as seen from the air.



Fig. 36.—The mouth of the Moose River and a portion of Ship Sands Island. The extensive marshes shown in this scene are heavily used by blue and snow geese and to a lesser extent by Canada geese in the autumn.

In Canada.—Before the southward migration from the breeding grounds takes place, a rather complex series of local flights occurs. About August 15, shortly after the young birds are on the wing, a movement begins to the coasts of Hudson and James bays. This is not a mass flight but a movement of family groups and small flocks from some of the production centers near the coast. The geese that have nested adjacent to the southwest coast of Hudson Bay fly north to the coast and then almost due east to Cape Henrietta Maria, figs. 2, 30 and 35; those that nested adjacent to the west coast of James Bay, north of the Ekwan River, fly east to the coast and then north to Cape Henrietta Maria. This cape is an isolated area of tundra attractive to the geese at this season because of the abundance there of blueberries (*Vaccinium* sp.), billberries (*Vaccinium uliginosum*), dwarf raspberries (*Rubus arcticus*), and crowberries (*Empetrum nigrum*). It is of interest to note here that flights to the sea coasts for the purpose of feeding on berries and other foods have been reported for other Canada goose populations in the north country [Newfoundland (Howley 1884); northern Ungava (Bent 1925, quoting Lucien M. Turner); and Labrador (Austin 1932)].

The geese that concentrate on the tundra of Cape Henrietta Maria remain there for varying periods before flying south. The length of time the geese remain in this region depends to a large degree upon the success of the berry crop, but probably all geese leave the cape by the latter part of September. At least half of the "cape geese," as they fly south down the west coast of James Bay, stop at Akimiski Island, where they concentrate on the wide flat marsh on the north side, a favorite feeding area. According to A. H. Michell of the Hudson's Bay Company, this flight usually takes place about September 15.

Most of the geese nesting south of the Ekwan River remain in the interior, although a few of them fly to James Bay, where they congregate in moderate-sized flocks in the coastal marshes about the river mouths, in country similar to that shown in fig. 36; others continue to the marshes of Akimiski Island.

Apparently, many of the geese that feed on Akimiski Island fly directly to the Jack Miner Sanctuary as soon as they leave the island. The Indians at Fort Albany claim that since Jack Miner started banding geese at his sanctuary they have killed only a few in the autumn.

A number of bands from geese banded at Horseshoe Lake have been recovered in summer from the Belcher Islands and the east coast of Hudson Bay in the region of Port Harrison, fig. 30. Whether these bands have been recovered from South Atlantic geese that strayed from their normal flyway and were banded at Horseshoe Lake, whether they were recovered from Mississippi flyway geese that strayed east of their normal flyway on their spring migration, or whether they were recovered from Mississippi flyway geese that nested west of James Bay and then struck out across the bays can be only conjectured on the basis of available data. In any case, many geese that are on the east coast of Hudson Bay in autumn migrate southward along the coast to the south end of James Bay, where they converge with the groups that have flown south along the west coast of James Bay.

Because band recoveries suggest a northward movement along the east coast of James and Hudson bays in the early autumn by geese that have nested inland from the south coast of James Bay, we believe that the final southward flights along the east coast of both bays may consist of at least some geese from three different populations. Geese of the South Atlantic population that nested along the east coast and on neighboring islands (Belcher and others) make up most of the flight; geese of the Southeast population probably are second in numbers; while individuals of the Mississippi Valley population are least numerous, fig. 7.

At points near the south end of James Bay, the South Atlantic geese split away from the Mississippi Valley and Southeast populations; portions of only the last two populations migrate through the Kingsville region in the autumn. The apparent mechanism of the splitting off of the southward flights along the east coast of James Bay into their various components, fig. 37, has been deduced

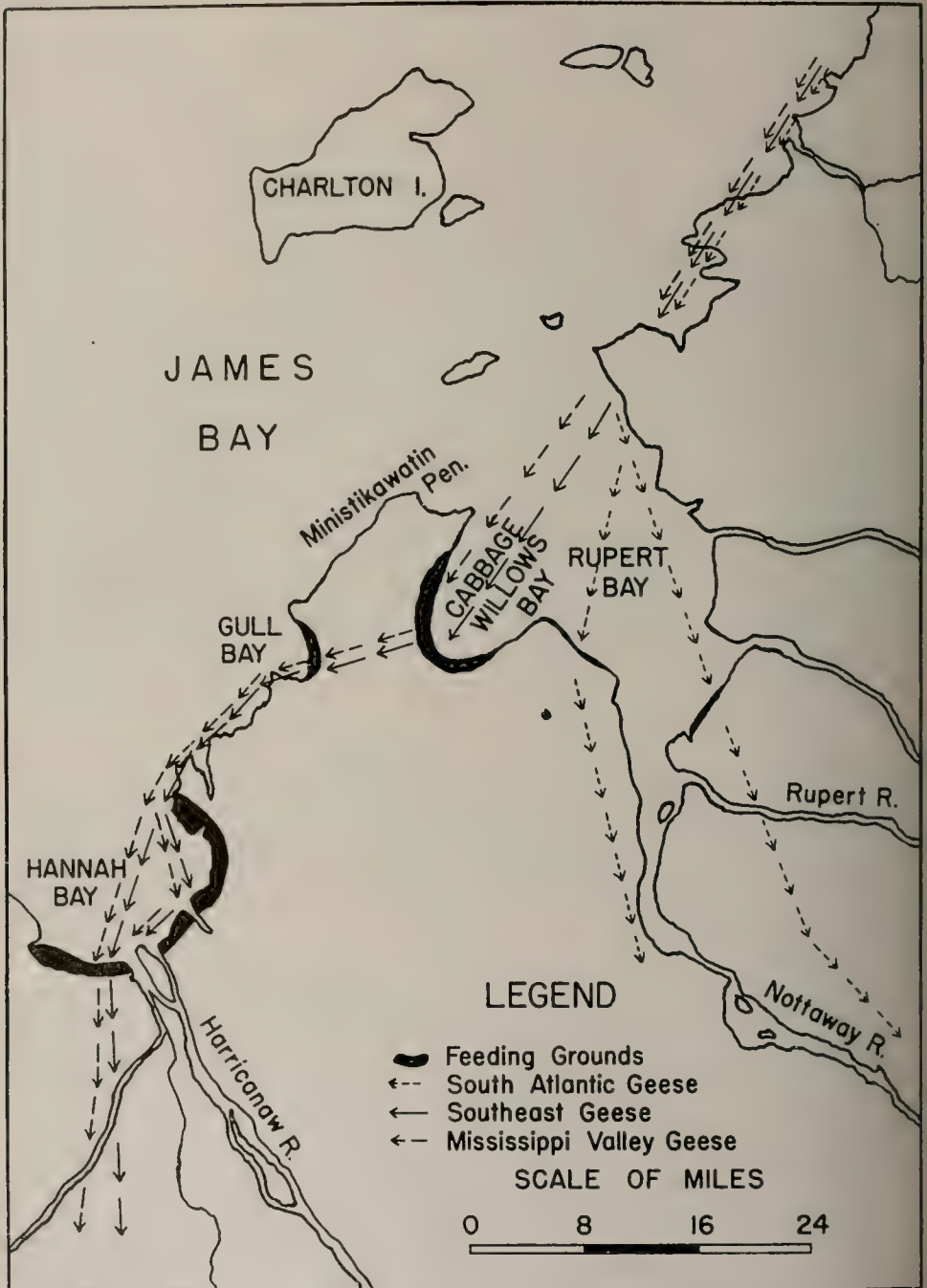


Fig. 37.—Probable migration routes taken by various populations of Canada geese at the southeast end of James Bay. The first splitting away from the combined flocks that migrate southward down the east coast of James Bay occurs somewhere along the northeast shore of Rupert Bay. A second splitting away occurs at or near the feeding grounds bordering Cabbage Willows Bay, the Mississippi Valley geese flying southward, the South Atlantic geese toward the southeast.

from a description of goose flights in the Rupert House area given to us by A. H. Michell, post manager at Rupert House.

The first splitting off of the combined autumn flights evidently occurs somewhere along the northeast shore of Rupert Bay, fig. 37. Some of the birds follow the northeast shore of Rupert Bay to the coastal marshes near the mouth of the Rupert River, where they congregate and feed; then they leave the James Bay region and fly southeast. Other flights cross Rupert Bay and feed in the marshes in the vicinity of Cabbage Willows Bay. At this point a second split occurs; some of the geese fly southeast, while the remainder follow a natural pass along a small stream and a series of muskeg lakes across the neck of the Ministikawatin Peninsula. These birds continue on to Hannah Bay, where they find final feeding grounds before departing from the James Bay region.

The geese that have remained in the muskeg west of James Bay, instead of flying to the coastal marshes, migrate south on a broad front, crossing into upper Michigan, Wisconsin, and eastern Minnesota, fig. 13. Probably they comprise the majority of the birds in the Mississippi Valley population, figs. 13-21.

In the United States.—Band recoveries indicate that the flights of Canada geese that enter the United States by way of upper Michigan, Wisconsin, and eastern Minnesota constitute the bulk of the Mississippi Valley population figs. 13-21. The flocks that migrate through Wisconsin in the autumn adhere principally to the eastern half of the state. Many of the flocks follow the west shore of Lake Michigan. Other flocks favor one of two other routes: (1) the valley of the Wisconsin River; (2) from Green Bay south to Lake Winnebago, the flights probably splitting south of Lake Winnebago, one sector going to the Lake Geneva area and the other following the Rock River.

According to Zimmerman (1943), the greatest concentration of Canada geese in Wisconsin during the autumn migration occurs in Adams, Columbia, Fond-du-Lac, Sauk, Walworth, and Waushara counties; the Arlington prairie in Columbia County and the Rock and Big Foot prairies in Walworth County attract the

greatest numbers. At the peak of the flight in 1941, about November 15, it was estimated that 15,000 to 20,000 geese were using Lake Wisconsin (Zimmerman 1942). Five thousand of these birds fed in the cornfields in the vicinity of Sumpster, Sauk County (Zimmerman 1942).

Appreciable numbers of Canada geese follow the west shore of Lake Michigan south, according to A. B. McDonald of Wadsworth, Illinois, who reported to Frank C. Bellrose of the Illinois Natural History Survey that each year flocks of Canada geese follow the shore line as far south as Zion, Illinois, at which point they leave the lake and fly southwestward. The exact route taken each year is said to remain identical.

The Canada geese entering the United States from the Miner Sanctuary by way of southeastern Michigan or northwestern Ohio constitute a part of the Mississippi Valley population. Recoveries of geese banded in the autumn at the Miner Sanctuary show that this segment of the Mississippi flyway population migrates almost straight southwest to the Ohio or lower Wabash rivers, stopping en route in considerable numbers at Lake St. Mary or Grand Reservoir, a 17,500-acre impoundment lying in Mercer and Auglaize counties, western Ohio. On leaving Lake St. Mary this group seemingly flies directly to the Ohio River valley, which it follows to Horseshoe Lake.

Another group of geese appears to migrate across lower Michigan from Saginaw Bay to the counties in the southwestern portion of the state. Some of these geese winter in the vicinity of the W. K. Kellogg Bird Sanctuary near Gull Lake, Kalamazoo County, and along the lower Kalamazoo River. The majority eventually continue southward, crossing north-central Indiana to the Wabash River bottoms; some of them join geese that have migrated south along the east shore of Lake Michigan and then fly either straight south to the Wabash and Ohio river bottoms or in smaller numbers fly southwestward directly to Horseshoe Lake.

Much of the Canada goose flight entering Illinois from Wisconsin in all likelihood traverses the length of Illinois on a fairly broad front, but band recoveries

Table 4.—Canada geese banded at the Horseshoe Lake Game Refuge and recovered in the United States away from Horseshoe Lake, seasons of 1940-41 through 1945-46.

SEASON OF BANDING	TOTAL GEESE BAND- ED	EARLY BAND- ING ¹	HUNTING SEASON			HUNTING SEASON OF RECOVERY AND DIRECTION OF RECOVERY FROM HORSESHOE LAKE																	
			Northern Zone	Central Zone	Southern Zone	Season of Banding			First Season After Banding			Second Season After Banding			Third Season After Banding			Fourth Season After Banding			Fifth Season After Banding		
						South ²	East ³	North ⁴	South ²	East ³	North ⁴	South ²	East ³	North ⁴	South ²	East ³	North ⁴	South ²	East ³	North ⁴	South ²	East ³	North ⁴
1940-41	315	0	10/1-11/29	10/16-12/14	11/2-12/31	0	0	0	3	0	7	1	2	1	0	0	5	0	1	2	0	0	2
1941-42	402	0	10/1-11/29	10/16-12/14	11/2-1/10	0	0	0	3	1	2	0	0	6	1	0	1	0	0	0			
1942-43	1,036	443	9/26-12/4	10/15-12/13	11/2-1/10	0	0	0	5	1	4	2	2	4	0	1	5						
1943-44	2,329	2,095	9/25-12/3	10/15-12/13	11/2-1/10	1	0	0	4	4	7	2	0	20									
1944-45	853	651	9/20-12/8	10/14-12/12	11/2-1/20	0	0	0	0	0	10												
1945-46	310	302	9/20-12/8	10/14-1/1	11/2-1/20	0	0	0															
Total	5,247	3,491				1	0	0	15	6	30	5	4	31	1	1	11	0	1	2	0	0	2

¹ Number of geese banded in fall up to 2 days before close of hunting in Southern Zone.

² Lower Mississippi River valley and coastal marshes of Louisiana.

³ Southeast states, Virginia to Alabama.

⁴ Sections of the Mississippi flyway north of the normal winter range of the Horseshoe Lake flock.

suggest that important numbers of birds follow the Illinois River to its juncture with the Mississippi River. At that point the Illinois River flight may be augmented by flocks (relatively few in number) that follow the Mississippi River southward toward Horseshoe Lake.

Because there has not been sufficient banding of Canada geese in southern parts of the Mississippi flyway, the flight lanes of Canada geese wintering on the lower Mississippi River, from Tennessee to Louisiana, are less apparent than the routes taken by flocks wintering farther north. Recoveries of geese banded at Kingsville, Ontario, in the autumn, figs. 14-21, suggest that many of the flocks migrate down the lower Ohio River valley to the Tennessee River, which they follow south instead of continuing on to Horseshoe Lake. Presumably, at a number of points these flocks later leave the Tennessee River and cross over to the lower Mississippi River.

Additional data indicating that considerable numbers of geese by-pass Horseshoe Lake to the east via the Tennessee River are found from band recoveries of geese raised at Seney National Wildlife Refuge in the northern peninsula of Michigan, fig. 39K. Of the total number of band recoveries made, the number reported from Arkansas was second only to the number reported from Michigan (Johnson 1947). These recoveries were made during the same period that heavy kills were occurring at Horseshoe Lake. It is, of course, assumed that the migrant birds from the Seney Refuge joined other wild flocks from the north or at least used the traditional paths of migration.

Recently Earl L. Atwood, manager of the Kentucky Woodlands National Wildlife Refuge, informed the senior author (personal communication, December, 1947) that the Tennessee River valley is a traditional flyway for Canada geese.

There is no evidence, either from observation or from band recoveries, to indicate that there is an important turnover in the flock using the Horseshoe Lake area in the autumn. According to our records, only one goose banded at the refuge has been taken an appreciable distance south of it the same season as banded, fig. 13 and table 4. If a turnover in the flock

occurs, it must be early in the autumn before many geese have been banded.

There is reason to believe that the Horseshoe Lake Refuge has acted as a "bottleneck" in that each year it has attracted increasing numbers of geese that previously have wintered along the lower Mississippi River. Few of these geese, having entered the refuge, would be expected to continue migration later in the season, except under pressure of extreme weather. Hence, they would augment the concentration surviving from previous years as well as contribute to the kill. The theory that the refuge acts as a "bottleneck" assumes that ingress of new birds from other areas exceeds the egress of old flock members. The decoying effect of a large concentration, abundant food, and a roost lake would seem the basis for a differential in favor of ingress.

We do not yet have satisfactory data on the migration routes of Canada geese wintering in western Louisiana. Recovery records of geese banded at the Miner Sanctuary and at Horseshoe Lake indicate that the migration routes of the Mississippi Valley population do not lie far west of the Mississippi River. Hence, the flocks that migrate through central or western Minnesota, Iowa, Missouri, and Arkansas, and those (possibly the same) that winter in western Louisiana, constitute part of a distinct population, the Eastern Prairie, but scattered band recoveries of geese banded at Horseshoe Lake and taken in Manitoba, South Dakota, western Minnesota, Louisiana, and eastern Texas are evidence that there is some exchange of birds between the Mississippi Valley population and the Eastern Prairie population.

Spring Migration Routes

There are too few spring band recoveries in the United States to depict accurately the northward migration routes of Mississippi flyway geese. Judged by trap records from the Miner Sanctuary, the spring movement is more directly northward and somewhat west of the autumn migration routes. Each spring in early March, a marked increase is noted in the numbers of Canada geese at Horseshoe Lake and at Hovey Lake, Posey County, Indiana. The latter area

harbors few geese in the autumn, but is host to large concentrations after the middle of February. It is conceivable that the late winter concentration may consist of geese of the Southeast population, which may take a more westerly route in their northward than in their southward migrations. Other important late winter or spring concentration points are the drainage districts near Putnam, Illinois (spring 1946 and 1947), the Horicon National Wildlife Refuge (Hopkins 1947), bottomlands of the Bark River in Wisconsin, farm lands at the south end of Lake Oshkosh in eastern Wisconsin, and Gull Lake in southwestern Michigan.

As most spring band recoveries are from the remains of geese shot the previous autumn, no differentiation is made between autumn and spring recoveries in figs. 13-21.

Apparently, after feeding in the rich farm lands along the migration routes in the United States and southern Canada, the flocks fly almost directly to the breeding grounds.

Time and Rate of Migrations

The autumn migration of geese wintering at Horseshoe Lake is spread out

over at least a 3-month period, the earliest migrants leaving James Bay in the forefront of September and the last reaching Horseshoe Lake in December, the exact dates depending on the severity of the weather.

Migration records from federal refuges and Horseshoe Lake, table 5, suggest that the outward movement of geese from the breeding grounds may be compared with a segment of the concentric waves produced by an object striking the surface of a body of water; the earliest flocks or migratory waves travel the greatest distances in the shortest periods of time and reach their wintering grounds in the far south before many other flocks have left the north country. First arrivals are noted at Horseshoe Lake and at federal refuges farther south as early as or earlier than they are recorded at refuges farther north. A similar picture has been found to be true for areas lying only short distances apart. Leopold & Jones (1947) reported that in 5 out of 6 years flocks of Canada geese were recorded near Madison, in Dane County, Wisconsin, 2 to 27 days before they were observed about 40 miles to the northwest, near the Wisconsin River, in Sauk County.

Table 5.—Dates of first recorded autumn arrivals of Canada geese at federal refuges and at Horseshoe Lake, Illinois, 1938-1944.

REFUGE	DEGREES NORTH LATI- TUDE	DATES OF FIRST ARRIVAL							AVER- AGE ARRIVAL DATE
		1938	1939	1940	1941	1942	1943	1944	
Rice Lake, Minnesota.....	47	—	10/12	10/26	10/15	—	10/6	10/1	10/10
Necedah, Wisconsin.....	44	—	10/20	10/12	10/8	10/8	—	—	10/12
Union Slough, Iowa.....	43	—	—	—	—	—	10/15	10/20	10/17
Upper Mississippi.....	See footnotes	10/22 ¹	—	10/13 ²	10/8 ³	10/9 ⁴	—	9/23 ¹	10/9
Squaw Creek, Missouri.....	40	—	9/24	10/15	—	10/4	—	10/10	10/6
Swan Lake, Missouri.....	40	10/14	10/4	10/4	10/10	10/11	9/17	—	10/5
Horseshoe Lake, Illinois....	37	—	—	—	9/10	9/21	10/1	9/24	9/22
Kentucky Woodlands (Gilbertsville Reservoir) ..	37	—	—	—	10/28	12/31	10/26	11/5	11/14
Reelfoot Lake, Tennessee....	36	—	—	—	—	9/27	9/12	9/8	9/16
Wheeler, Alabama.....	35	—	11/4	10/8	10/18	12/8	11/2	11/4	11/2
White River, Arkansas.....	34	10/19	10/17	—	10/1	9/27	9/25	10/1	10/5
Lacassine, Louisiana.....	30	—	9/28	10/12	12/21	—	10/1	9/2	10/1
Sabine, Louisiana.....	30	10/20	10/14	9/27	9/25	9/12	10/30	10/5	10/6
Delta, Louisiana.....	29	—	10/27	10/6	—	10/18	10/26	10/25	10/20

¹ Section of refuge unknown.

² Savanna, Illinois, District, 42° N. Latitude.

³ Guttenberg, Iowa, District, 43° N. Latitude.

⁴ Bellevue, Iowa, District, 42° N. Latitude.

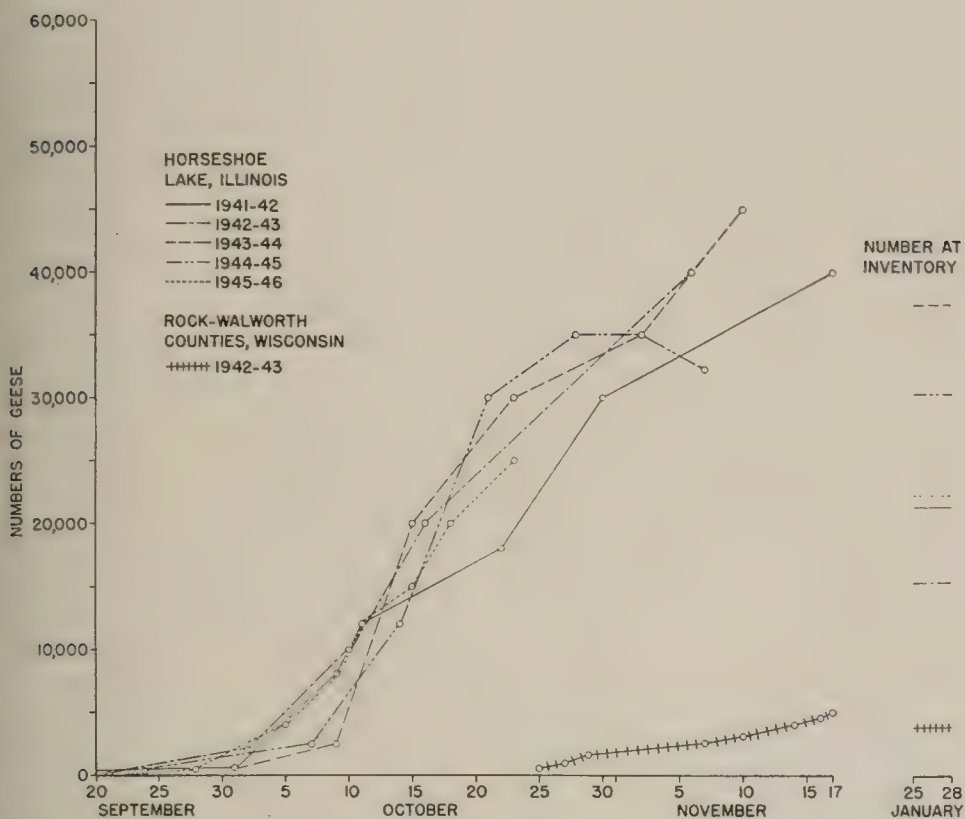


Fig. 38.—Build-up of the Canada goose flock at Horseshoe Lake during the autumn and winter of the years 1941-1946. Also shown is the build-up of the Canada goose flock in Rock and Walworth counties in the autumn and winter of 1942-43 (from Zimmerman 1943).

The build-up of autumn concentrations at Horseshoe Lake is shown in fig. 38. As the majority of the geese wintering at this refuge arrive before the bulk of the kill has been made farther north, probably the flocks that leave the breeding grounds later, and winter farther north, contribute most to the kill in areas north of the refuge.

Spring migration movements appear to be more leisurely than the flight south, but this impression may be created by flocks of nonbreeding adult or yearling geese that are under no stimulus to reach the breeding grounds at an early date. We have seen several hundred geese in the vicinity of Lake Wisconsin throughout the first week in May, and Hopkins (1947) states that the last flock in the Horicon Marsh area in 1947 remained until May 8. On the other hand, the

arrival of the first flocks in the James Bay region is quite punctual, generally between April 15 and 25, which is the time of the goosemoon, "nisku pesim," of the Cree Indians. In most years, the earliest flocks arrive on the breeding grounds 2 to 3 weeks before the break-up of the major rivers, table 6.

George MacCloud, a lifelong resident of the James Bay area, reported to the senior author that a second flight of Canada geese generally takes place about June 10. These late geese are said to be in large flocks, whereas most of those that arrive earlier are paired. He thought that the late arrivals were largely young of the previous year. Although we have been in the bay area during June, we are unable to confirm, by personal observation, the "flight of stragglers."

However long the northbound Canada

Table 6.—First arrival or first kill of Canada geese at Fort Albany, Ontario, and date of breakup of the Albany River.*

YEAR	ARRIVAL OF CANADA GEESE		DATE OF BREAKUP OF THE ALBANY RIVER	NUMBER OF DAYS BETWEEN FIRST ARRIVAL OF GEESE AND RIVER BREAKUP
	Date	Comment		
1884.....	May 1.....	First goose observed.....	May 17.....	16
1885.....	April 26.....	First goose observed.....	May 15.....	19
1888.....	April 21.....	First goose observed.....	May 12.....	21
1889.....	April 12.....	First goose observed.....	May 6.....	24
1891.....	April 15.....	First geese observed.....	May 14.....	29
1896.....	April 15.....	First geese observed.....	May 10.....	25
1897.....	April 12.....	First geese observed.....	May 7.....	25
1898.....	April 14.....	First geese observed.....	April 27.....	13
1900.....	April 6.....	First goose observed.....	May 2.....	26
1901.....	April 18.....	First goose killed.....	May 1.....	13
1902.....	April 14.....	First goose killed.....	May 15.....	31
1903.....	April 23.....	First geese observed.....	May 20.....	27
1904.....	April 23.....	First geese observed.....	May 8.....	15
1913.....	April 17.....	First geese observed.....	April 28.....	11
1914.....	April 21.....	First goose killed.....	May 6.....	15
1918.....	April 19.....	First goose killed.....	—	—
1919.....	April 19.....	First goose killed.....	—	—
1920.....	April 25.....	First geese observed.....	—	—
<i>Average</i>				20.6

* Data on the arrival of Canada geese before 1901 and most data on breakups from Lower (1915); arrival data on Canada geese 1901–1920 from Fort Albany diary of Bishop Robert John Renison and other local sources.

goose flocks may linger in the United States, the final lap over the forested areas of Canada is apparently often made in a single day. Miner (1929) stated that frequently, when flights of geese have left his refuge at a half hour before sundown, he has wired the news ahead to towns lying north between Kingsville and James Bay. The following morning, generally between 6 and 8 o'clock, large flights have been seen over Cochrane, Ontario, a town about 490 miles north of Kingsville. If their course was fairly direct, and if it is assumed that the geese that left the Miner Sanctuary were the ones sighted over Cochrane, a not unwarranted assumption, their average speed was 35 to 40 miles per hour.

A few flocks stop to feed each spring on the farm lands of the clay belt in central Ontario; the New Liskeard area was host to migrating flocks in 1947. In early May of that same year, flocks held up by severe winter conditions remained in the Kapuskasing area sufficiently long to warrant artificial feeding; little natural food was available, as the country was still under several feet of snow, and all rivers and lakes were frozen. Despite this fact, a large flight of Canada geese

was reported over Frazerdale the night of May 4, and the following day the first big flight was observed in the Moose River country, nearly 2 weeks before the breakup of the Moose River, which occurred on May 17.

No attempt has been made in the present study to compile additional data on the correlation of Canada goose movements with the advance of the isotherm of 35 degrees F., a correlation reported to hold only for the vanguard of migrants (Lincoln 1939).

WINTER CONCENTRATIONS

The Canada geese of the Mississippi River valley winter from the latitude of southern Wisconsin to the Gulf Coast of Louisiana, using definite concentration areas during the winter season, as well as during the migration periods. They are hardy birds, able to withstand winters of the severity of those occurring in southern Wisconsin and southern Ontario without ill effect, as long as they are provided with abundant food and a water supply. When rest lakes in northern areas become frozen over, the flocks resort to open streams for drinking water, but the lake ice pro-

vides acceptable roosting sites. When the local food supply is exhausted or covered with snow, or when feeding is curtailed,

as at the Miner Sanctuary in early December, the geese in the northern sectors of the flyway migrate farther south.

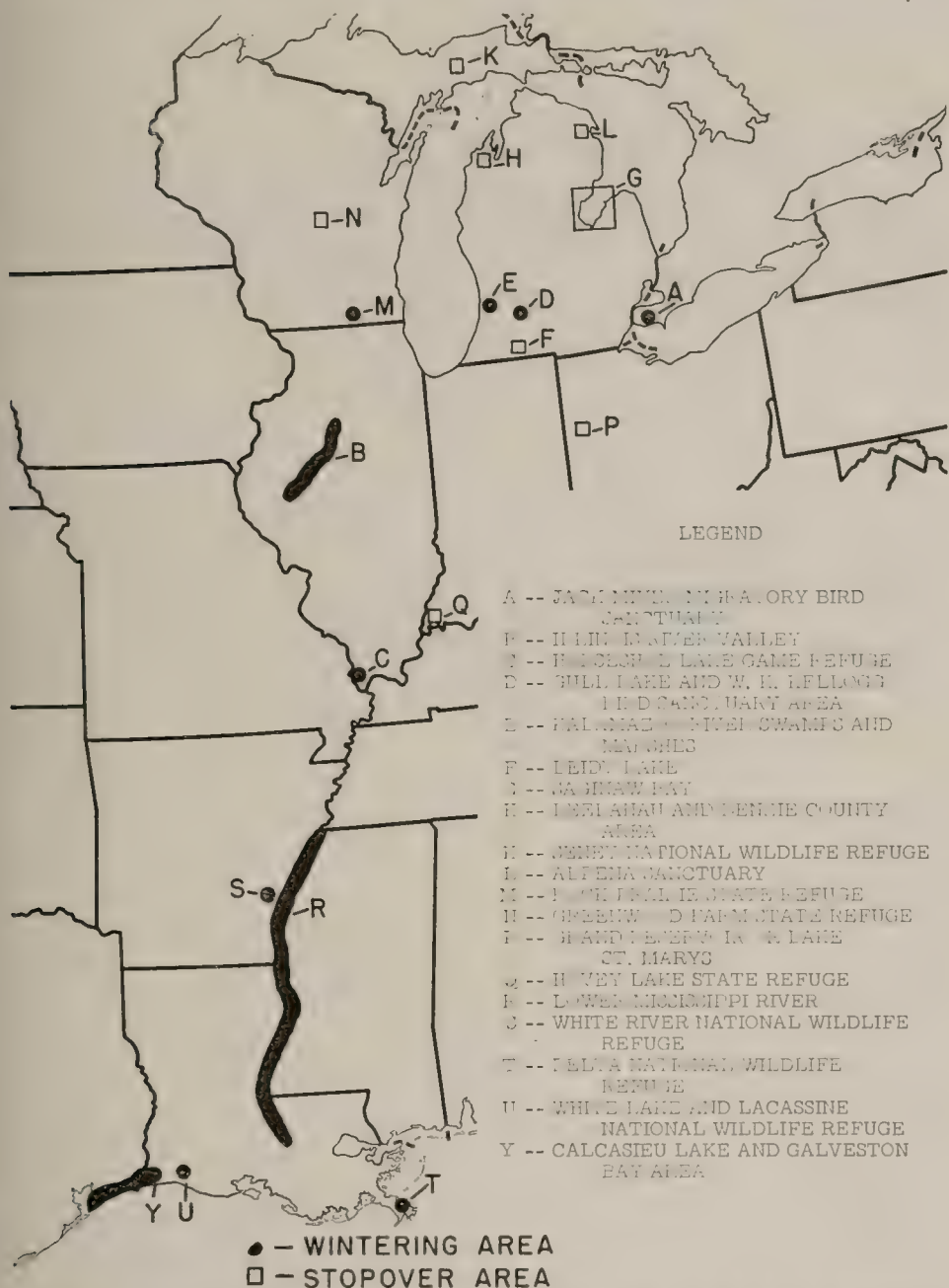


Fig. 39.—Location of important concentration areas for Canada geese of the Mississippi Valley population.

Each January an inventory of the waterfowl populations wintering in the United States is made by the United States Fish and Wildlife Service and co-operating agencies, assisted by selected private individuals. The January inventories have produced useful information, particularly in regard to population trends but, because these inventories are taken over a limited period of time (4 days), in some areas they have been subject to considerable error in past years. For example, the immense coastal marshes of Louisiana, which are notoriously difficult to traverse on the ground, cannot be covered adequately except by plane. Because thorough aerial censuses of the Canada goose population in Louisiana were not made before the winter of 1943-44, and because adequate data are lacking for many other parts of the flyway prior to that winter, we do not consider the population data previous to that date to be of sufficient reliability to meet present-day management needs. Even some of the data in table 7, particularly the 1944-45 figures for the populations in Arkansas and on a considerable portion

of the lower Mississippi River, may not be of sufficient reliability because complete coverage by aircraft was not possible.

For reasons explained in the section "Autumn Migration Routes," we believe that the flocks of western Louisiana probably are not an integral part of the Mississippi Valley population. Nevertheless, they should be considered along with the Mississippi Valley population in order to detect whether major population shifts occur between the flyways in some years and to determine the effect that kills in the upper Mississippi River valley may have on the western Louisiana populations. A brief survey of the various concentration areas and the populations using them follows.

Jack Miner Bird Sanctuary

The Jack Miner Bird Sanctuary, located in the rich farm lands of Essex County, Ontario, figs. 39A and 40, 4 miles from Lake Erie, was one of the first waterfowl refuges established in North America. The history of this refuge and of Jack Miner's work with Canada geese has a bearing on discussions

Table 7.—Population of Canada geese in the Mississippi River valley, 1943-44 through 1946-47. Data are from the annual January inventories, except as noted.

STATE OR OTHER AREA	SEASON			
	1943-44	1944-45	1945-46	1946-47
Michigan.....	4,220	2,200	2,343	3,512
Wisconsin.....	6,350	4,100	4,310	5,000
Minnesota.....	—	5	100	—
Ohio.....	248	—	—	105
Indiana.....	343	750	985	1,369
Illinois (Mason County).....	925 ¹	800 ¹	360 ¹	} 31,649 ²
Horseshoe Lake.....	37,000 ³	30,000 ⁴	22,000 ³	
Iowa.....	125	6	—	—
Kentucky.....	3,720	2,280	1,200	1,230
Mississippi River (Tenn.-Miss. line to White Castle, La.).....	3,300 ⁵	10,000 ⁶	1,650	7,540
Arkansas.....	5,000 ⁵	10,500	5,400	800
Missouri.....	3,300	5,440	665	2,370
Louisiana Delta.....	1,000 ⁵	1,000 ⁵	} 10,000 ⁷	} 8,065 ⁷
Western Louisiana.....	11,000 ⁵	12,000 ⁵		
Total.....	76,731	79,181	49,013	61,640
Total, exclusive of western Louisiana	65,731	67,181	—	—

¹ Census by Frank C. Bellrose, Illinois Natural History Survey.

² Of the number of Canada geese in Illinois, about 30,000 were at Horseshoe Lake and 800 at the Union County refuge.

³ Census by Paul S. Smith, United States Fish and Wildlife Service, and Harold C. Hanson at January inventory.

⁴ Average of estimates by Robert H. Smith, Paul S. Smith, and Frank C. Bellrose after hunting season.

⁵ Census by Robert H. Smith.

⁶ Total for Tennessee and Mississippi combined in January inventory.

⁷ Inventory figure for all of Louisiana. According to Richard H. Griffith, United States Fish and Wildlife Service, 1,500 Canada geese were at the Delta National Refuge and 5,440 at the Lacassine and Sabine National Wildlife refuges in the winter of 1946-47.

in this paper and is also of general interest.

Jack Miner (1923) built his first pond and set out decoys to attract geese in 1904, but did not lure in a family of geese until 1908. The numbers of geese using the refuge built up slowly in the early years,

acre homestead area. About 100 acres are planted to rye and timothy, the remainder to corn, which constitutes the only grain fed to the geese. Fields of timothy, which have been cut for seed, are said to make ideal pastures for Canada geese and are heavily grazed. Approxi-



Fig. 40.—View of the main pond and feeding grounds at the Jack Miner Bird Sanctuary, Kingsville, Ontario. Contact of the geese with human beings is avoided whenever possible. Corn is distributed at night, and visitors remain concealed while observing the geese.

and until 1915 the refuge attracted Canada geese only in the spring. In later years the autumn flight equaled the spring flight in size.

Efforts at trapping and banding Canada geese did not succeed until 1915, and large-scale bandings were not accomplished until nearly 10 years later. Table 2 presents the best available data on the numbers of Canada geese banded at the Jack Miner Bird Sanctuary in the autumn.

The Miner homestead, ponds, and feeding grounds consist of 17 acres. All feeding is done around the ponds, but a few rye and timothy fields are planted as retreats and sources of food to be used when the geese on the ponds are disturbed. Additional farm land, owned by the Jack Miner Migratory Bird Foundation, Inc., amounting to 400 acres, surrounds the 17-

mately 20,000 bushels of ear corn are fed during the autumn and spring seasons; when there is an appreciable local kill the corn is fed more heavily than at other times.

By Proclamation and Order in Council of the Provincial Government, no shooting is permitted on an additional 1,600 acres of land neighboring the 400 acres owned by the Miners. Thus, the geese are protected in all directions from the central feeding grounds by a buffer strip about 1 mile deep.

A few geese arrive at the refuge by late September. Noticeable increases in numbers usually occur between October 10 and 15, and peak numbers are reached by about November 10. There is a constant renewal of the population as some individuals continue their migration south and others arrive from the north. The bulk

of the autumn flock leaves by late November or early December. In some years prior to World War II, as many as 5,000 geese were reported to have remained all winter. Some of these wintering geese from the autumn flight have received "S" marked bands in the spring along with birds that have wintered at Currituck Sound and Lake Mattamuskeet, thereby explaining why some spring bands are subsequently recovered in the Mississippi River valley, fig 12.

Illinois

Of the areas in Illinois important to migrating and wintering flocks of Canada geese, the two most important are the Illinois River valley and the Horseshoe Lake Game Refuge in Alexander County at the southern end of the state.

Illinois River Valley.—Canada geese have been reported from 23 bottomland lakes in the Illinois River valley, fig. 39*B*, but regularly from only seven lakes, table 8. These lakes act chiefly as roost areas; feeding is done in the cultivated uplands and in some drainage districts. Geese of five of the Illinois concentrations disperse to feed as follows: Beebe Lake geese depend largely on the winter wheat and the corn of Duck Island; Lake Chautauqua and Clear Lake geese feed mainly in the cultivated fields of Mason County; Crane Lake and Jack Lake birds seek most of their food in or near a 1,000-acre

private club 2 miles southeast of Bath. Flocks frequenting Goose Pond and Lake Senachwine (the part formerly known as Swan Lake) have not been observed feeding in any particular sector. In general, feeding areas are within 7 miles of a roost lake. Population data for the above areas are summarized in table 8.

Horseshoe Lake Game Refuge.

The most important Canada goose wintering ground in the Mississippi River valley in recent years, the Horseshoe Lake Game Refuge, with its surrounding area, figs. 1 and 39*C*, during the period of this study harbored approximately 50 per cent of the goose population of the flyway for varying autumn and winter periods. Because of inadequate food supplies on the refuge, as well as intense hunting pressure in surrounding privately owned fields, the flock fed in most winters over a 15-mile radius. The majority of the geese roosted within the refuge each night, although some flocks resorted to islands and bars in the Mississippi River.

The lake, fig. 41, 1,200 acres in size, of an oxbow type common to the bottomlands in the flood plain of the Mississippi River, in many places is 200 or more yards in width and 4 to 6 feet in depth. A dam maintains fairly stable water levels, but most of the land enclosed by the lake is subject to flooding when the Mississippi or Ohio River reaches high flood stage. Open water surrounds the island except for a

Table 8.—Canada goose populations in three regions of the Illinois River valley, autumns of 1938–1946.

YEAR	BATH REGION (Jack, Crane Lakes)		CHAUTAUQUA REGION (Chautauqua, Clear, Beebe Lakes)		PUTNAM REGION (Goose Pond, Lake Senachwine*)		APPROXIMATE AVERAGE NUMBER IN VALLEY
	Peak	Average	Peak	Average	Peak	Average	
1938.....	1,420	800	75	22	?	60	832
1939.....	2,100	520	500	34	?	100	654
1940.....	800	509	250	110	?	83	702
1941.....	1,500	391	337	84	37	?	475
1942.....	1,340	1,150	325	400	80	60	1,610
1943.....	1,900	500	300	425	400	?	925
1944.....	1,600	400	150	400	14	?	800
1945.....	1,400	0	330	360	46	?	360
1946.....	500	285	430	281	190	86	652
Total.....	12,560	4,555	2,697	2,116	767?	389?	7,050
Average..	1,398	506	300	235	—	—	784

* Part of Lake Senachwine formerly known as Swan Lake.



Fig. 41.—View of the east arm of Horseshoe Lake. The large open expanses of the lake are favored by the geese for roosting purposes.



Fig. 42.—The greater portion of Horseshoe Lake is open water, but the north and south portions have heavy stands of live and dead cypress and tupelo gum trees. A dam maintains fairly stable water levels except when the Mississippi or the Ohio River reaches high flood stage.



Fig. 43.—Aerial view of Canada geese on Horseshoe Lake in November, 1945. The population of the entire flock could be counted with a considerable degree of accuracy if suitable aerial photographs were available.

small portion at the north end, where the lake is swamplike and has an irregular stand of tupelo gum and cypress trees, fig. 42. Gums and cypresses border the re-

mainder of the lake, and in some places the cypresses extend entirely across the lake.

During late years of this study the refuge contained about 3,660 acres. The

Table 9.—Number of Canada geese using the Horseshoe Lake Game Refuge, 1928–29 through 1946–47.

SEASON ¹	PEAK NUMBER	NUMBER AT JANUARY INVENTORY	TOTAL LOSS (INCLUDING CRIPPLING LOSS, FROM TABLE 15)	APPROXIMATE NUMBER OF GEESE TO ARRIVE AT REFUGE DURING FALL AND WINTER
1928–29.....	1,000–1,900 ²	—	—	—
1929–30.....	7,000–8,000 ²	—	—	—
1932–33.....	30,000 ²	—	—	—
1940–41.....	45,000	17,000	—	—
1942–43.....	55,000	15,000	—	—
1943–44.....	50,000	37,000	15,980	53,000
1944–45.....	35,000	30,000	10,549	40,500
1945–46.....	26,000	22,000	7,117	29,100
1946–47.....	—	31,641	—	—

¹ The term *season* refers to the period of time in autumn and winter that the geese are at the refuge.

² From Uhler (1933). Other censuses except last two by Illinois Natural History Survey staff and Paul S. Smith: 1945–46 and 1946–47 censuses by Survey staff and Robert H. Smith.

island has an area of 1,360 acres, of which 1,200 have been farmed in recent years to produce food for the geese. The remaining acreage supports some of the finest virgin bottomland timber in the state. Of the cultivated portion of the island usually 300 to 400 acres are planted to corn and 700 acres sown to wheat, but these acreages have varied considerably from year to year. In the last several years all crop land on the island has been planted in corn. Wheat or corn is sown on the 100 acres of the refuge adjoining the east shore across from the island.

Many of the published statements in recent years regarding the size of the Canada goose flock at Horseshoe Lake have not been in agreement. The result has been confusion in the minds of the public. While a few "census figures" have been based on pure guesswork and are therefore unreliable, many of the differences in published data may be related to the times of the year the censuses were

taken, and whether they included only the number of birds alive on certain dates or the total number arriving at the refuge in any given year. The population data given in table 9 summarize the census figures for several years.

Population estimates of the Horseshoe Lake flock since 1939 have been made by staff members of the United States Fish and Wildlife Service and the Illinois Natural History Survey, table 9. These estimates have been made by visually dividing the flocks into blocks, counting the number of geese in the sample blocks when the great bulk of the geese are feeding in the wheat fields on and near the refuge, and then using the sample counts to calculate the total population. The practice in some years has been to make periodic estimates from the time the first geese arrived in late September until peak populations have been reached in late autumn. Since 1944, aerial censuses just before and after the hunting seasons have



Fig. 44.—Aerial view of Burnham Island and adjacent bars in the Mississippi River, 4 miles west of Horseshoe Lake. Prior to the establishment of the refuge, Canada geese wintered in large numbers on similar bars and islands of the Mississippi River, from Chester to Cairo, Illinois. Geese have made some use of these islands even since the refuge was established.

been made at Horseshoe Lake and nearby areas, figs. 43 and 44. Population figures for 1941-42 through 1945-46 are shown graphically in fig. 38.

Michigan

In Michigan there are three major concentration areas and two of minor importance.

Kalamazoo River Bottoms and Nearby Lakes.—The Kalamazoo River bottoms and a number of lakes in the southwestern section of the state constitute the most important region in Michigan for concentrations of migrant and wintering Canada geese, fig 39. This general area includes three specific concentration sites.

1. Gull Lake and the W. K. Kellogg Bird Sanctuary and Farms are located in Prairieville and Barry townships in Barry County and in Richland and Ross townships in Kalamazoo County, fig. 39D. Gull Lake, with an area of 3,000 acres, is designated as a rest lake. Hunting is prohibited on the quarter-mile strip surrounding this lake and on the Kellogg tract of 600 acres.

The above district lies on an extensive outwash plain and is characterized by small lakes and kettle holes. Some nearby sections are too hilly to be farmed, but hay, corn, and wheat are raised extensively on the less hilly sections. The geese feed in the cultivated upland fields and also they are hunted there.

In 1945, the maximum autumn population in the area was 5,000 birds, and about the same number were present during the peak of the 1946 spring migration. The wintering population usually varies from 1,000 to 2,000, but may be considerably less for several weeks in midwinter. In 1944-45, 500 geese wintered at Gull Lake (Dr. Miles D. Pirnie, then in charge of the sanctuary, personal communication). Normally a majority of the birds leave by mid-January and return again by mid-February. Weather determines their movements; usually a portion of Gull Lake remains open throughout the winter, and waste grain is generally available in the uplands for geese that winter in the area.

2. The Kalamazoo River swamps and marshes, fig. 39E, principally the Potta-

wattomie and Ottawa marsh areas, the latter a part of the Swan Creek Wildlife Experiment Station located in Heath, Manlius, and Valley townships, and the Todd Farm Sanctuary in Ganges and Clyde townships near the Kalamazoo River, all in Allegan County, are some of the most important concentration grounds for Canada geese in Michigan. Each site differs somewhat from the others and there is a free interchange of birds from one area to the other.

The Pottawattomie and Ottawa areas consist of 2,800 acres, principally marshy bottomlands with adjacent timbered areas. These areas serve as both private and public hunting grounds.

The Swan Creek Wildlife Experiment Station has a 550-acre sanctuary of partially flooded land, once farm land, and timbered bottomland.

The Todd Farm Sanctuary comprises 1,500 acres of drained lake-bottom farm land. This sanctuary furnishes both feeding and resting sites. Hutchins Lake, north of the farms, is used by geese as a rest lake in the autumn. A spring-fed creek crossing the farm remains open through the winter, and food is available to the geese in the cultivated fields.

The greatest concentration of geese recorded in the above sections was 6,000, in the autumn of 1945. The wintering flock was estimated at 2,000. Both figures are said to represent spectacular increases in comparison with those of previous years. In 1944 the wintering flock was estimated to be only 400.

3. A 250-acre sanctuary at Leidy Lake in Leonidas Township, St. Joseph County, fig. 39F, serves as an important spring concentration point; over 2,000 geese were estimated to be on the area in 1946. It is used less in the autumn, 300 to 400 being average numbers of geese present at that time.

Saginaw Bay.—Saginaw Bay is a major concentration area for both autumn and spring flights of Canada geese, fig. 39G. The spring flights may consist largely of South Atlantic geese en route north from the Miner Sanctuary. The geese do not linger long at Saginaw Bay in the autumn because of the absence there of sanctuaries. They have been forced by hunting pressure to reverse their normal

daily routine, feeding after dusk in the grain fields and roosting in daylight hours on the open waters of the bay. They do not winter in this sector, as there is no open water.

The best estimates available place the maximum numbers frequenting the bay during the autumn or spring migrations at about 15,000 birds.

Leelanau and Benzie Counties.—Leelanau and Benzie counties in Michigan, fig. 39H, constitute a less important concentration area than the Kalamazoo River or Saginaw Bay areas. A number of scattered sites are favored: Glen Lake and about four sections of hilly grassland in Empire Township, Leelanau County, and Lake Ann, Upper Platte River, and Platte Lake in Benzie County. A 1,200-acre refuge recently established in Empire Township provides feeding and resting areas.

Canada geese have used this area as a regular stopping place for only about 10 years. In recent years as many as 2,000 geese have frequented it regularly, but few winter in the area; there were about 50 in 1945. Some Canada geese may nest in this region.

Other Michigan Areas.—There are two other concentration areas in Michigan of less importance than the above. The Seney National Migratory Waterfowl Refuge, fig. 39K, consists of 30,000 acres surrounded by a vast area of wild land. The autumn concentration in 1945 was estimated at 3,000 geese. The spring maximum was 2 500.

The Alpena Sanctuary, fig. 39L, comprises 500 acres of land on the Thunder Bay River in Alpena Township, Alpena County. Geese stocked at this refuge have attracted as many as 400 migrants in the autumn.

Wisconsin

In Wisconsin there are two refuges or concentration areas of importance.

Rock Prairie Refuge.—The Rock Prairie Refuge, fig. 39M, consisted of 640 acres when established in 1936. Before the refuge was relocated, it lay partly in Richmond Township, Walworth County, and partly in Johnstown Township, Rock County. In 1945 the refuge was shifted $3\frac{1}{2}$ miles to the west so that it lay entirely within Rock County.

The entire refuge is in cultivated prairie uplands and is used for feeding only. Since feeding was initiated in 1940, between 25 and 45 tons of corn have been fed each season. The geese that frequent this refuge in the autumn and winter usually fly to Lake Geneva and Lake Koshkinong for roosting.

Canada geese do not remain in southern Wisconsin during severe winters. In 1945–46, local estimates placed the wintering flock at 3,000. In 1942, 4,500 geese wintered in these two counties (Zimmerman 1942). Peak autumn populations in Rock and Walworth counties have generally varied from 4,000 to 6,000 birds. The build-up in numbers of geese in the autumn of 1942 is shown graphically in fig. 38.

Greenwood Farm Refuge.—The Greenwood Farm Refuge, established in 1940, contains 1,751 acres. It is situated in Hancock and Deerfield townships, western Waushara County, fig. 39N. Although it is intended primarily as a rest area, in some parts of this refuge farmers are paid to leave corn standing in the fields for the geese. The flocks roost on the sand bars of the Wisconsin River, about 20 miles to the west. The refuge was first used by a few geese in 1942; as many as 3,000 birds had been reported on the area by 1946.

Ohio

Lake St. Marys, or Grand Reservoir, fig. 39P, a 17,500-acre impoundment in Mercer and Auglaize counties, is heavily used by Canada geese in migration, but few geese winter there or in other parts of Ohio. January inventory figures, 1941–1946, show an average of only 400 Canada geese in the entire state; inventory figures for the state, 1936–1941, averaged 1,600 per year.

Indiana

Hovey Lake, fig. 39Q, the most important wintering area for Canada geese in Indiana, is located in Posey County in the extreme southwestern tip of the state, 4 miles from the confluence of the Wabash and Ohio rivers. The lake and adjoining marsh and swamp land, totaling 900 acres, were purchased in 1938 with funds made available through the Federal Aid

in Wildlife Restoration Act. The lake, nearly a half mile wide and three-quarters of a mile long, has an area of about 400 acres. Bald cypress is found around certain parts of the lake, but willow, elm, and soft maple, with an understory of buttonbush, occupy most of the shore line.

Approximately half of the lake is open to waterfowl hunting; the remainder is a refuge. No supplemental feeding is carried out on the refuge sector, a factor that may partially explain why the geese that use the area have retained their wildness. Nearby wheat fields are cropped by the geese to a considerable extent, but no serious damage has been reported. During the winter period the geese do much of their feeding in overflow, bottom-land cornfields that have been harvested with mechanical pickers.

There are seldom more than 300 geese in the vicinity of Hovey Lake during the hunting season. Maximum numbers during three recent winters are as follows: 1,000 on January 8, 1944; 1,500 on January 20, 1945; and 2,000 on January 27, 1946.

Arkansas

The geese wintering in the lower White River and Arkansas prairie area, fig. 398, use several distinct types of habitat: the flood-plain swamp lakes of the White River National Wildlife Refuge, the neighboring prairie area of Arkansas County, and the sand bars of the lower Arkansas River and adjacent parts of the Mississippi River.

The flood-plain lakes are shallow, cypress-rimmed oxbows, devoid of submerged vegetation and used by the geese only for roosting. The geese make daily flights from these lakes to the prairie for feeding. The prairie is intensively cultivated; rice, winter oats, soybeans, and lespedeza are the principal crops. The practice of leaving the rice fields fallow periodically and using them for pasture makes attractive foraging areas for geese, as the ground between the old rice levees is frequently flooded or at least wet during the winter.

Because of the difficulty of censusing the extensive areas of bottomland swamps, we believe that in most years our data on populations in Arkansas are not reliable. In the winter of 1943-44, the population was successfully censused and estimated to be 5,000, but we are unable to state with any certainty what the population was in prior or subsequent years, as the birds wintering in this region occasionally use the Mississippi River bars and may have been included in the estimate for the Mississippi River area. Duplications in the inventory figures for Arkansas and the lower Mississippi River in 1944-45 may account for the indicated increases for this region in that winter and partially explain the apparent sudden great drop in the total population of Mississippi flyway geese in the following year, table 7.

Lower Mississippi River

Islands and bars in the Mississippi River attractive to wintering Canada

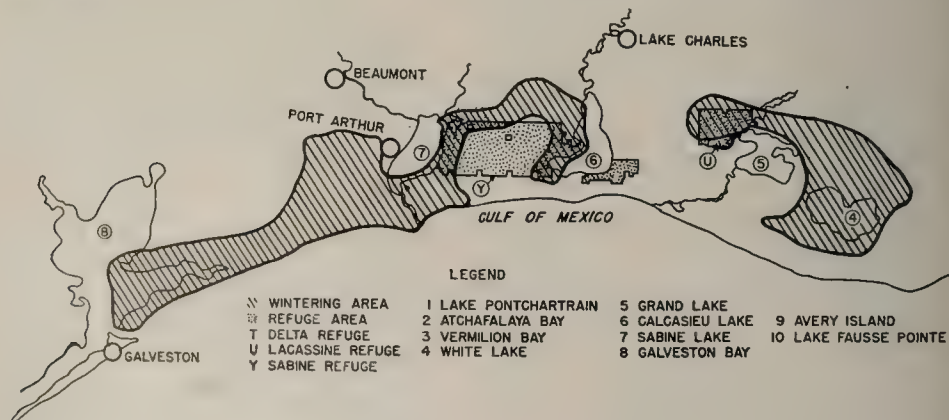


FIG. 45.—Location of wintering grounds of Canada geese on the coast of the Gulf of Mexico.

geese extend north to Chester, Illinois, and south to White Castle, Louisiana. However, except for scattered flocks, few Canada geese have wintered on the Mississippi River between Cairo, Illinois, and the Tennessee-Mississippi state line in recent years.

The portion of the Mississippi River used by Canada geese throughout the winter, fig. 39R, has an area, from levee to levee, of well over 1,500 square miles. In this huge expanse of territory the channel has constantly shifted by cutting and tearing on one side and depositing on the other; the result is a labyrinth of chutes and oxbows that have formed numerous islands and bars. Each island usually has one or more sand bars, and most of the bends in the channel have bars on the inside, fig. 44. Portions of the higher islands and bars, covered with small switch willows, grasses, and sedges, are used as feeding areas by the geese. At times, the bark of the small switch willow appears to be staple food of geese throughout the area.

The geese using this section of the river are widely scattered; usually they are in small or medium-sized flocks, but occasionally in large flocks. They show a preference for certain bars, which they use year after year. Varying water stages affect the accessibility of the bars to the geese and may cause the flocks to shift about when water levels change rapidly.

In primitive times the geese depended on forage produced on sand bars and in shallow flood-plain lakes, since there were then no cultivated crops in the bottom-land country. Early agricultural developments tended to keep them on the bars in the southern sections of the flood-plain and upper delta country because cotton and sugar cane were the only crops extensively raised. Each year increasingly large acreages are planted to winter grains and legumes in the north and central portions of the bottomlands, thereby increasing the food resources for the geese in that section.

The habitat at Grand Lake and Lake Fausse Pointe, fig. 45, while near the coast, is of the sand-bar type rather than marsh. The geese are found on the upper ends of the lakes where the distributaries of the Atchafalaya River have formed a subdelta, creating conditions very similar to those found on the river sand bars. The geese sometimes work back and forth across the Atchafalaya swamp between Grand Lake and the Mississippi River, as less than 25 miles separate the lake from White Castle, Louisiana, the nearest point on the river.

Our data on goose populations in this sector of the valley are meager. Estimates made by the United States Fish and Wildlife Service have varied from 1,600 to 10,000 geese between 1944 and 1946. Accurate census figures are especially



needed from the lower Mississippi River each year, because data from this area are apt to indicate to what extent kills made in the Horseshoe Lake region are at the expense of populations wintering below Cairo, Illinois.

Coastal Marshes

The coastal marshes of Louisiana and east Texas extend from the mouth of the Mississippi River west to Galveston Bay. In this vast expanse of marsh, totaling over 5,000,000 acres, less than 700,000 acres are inhabited by Canada geese. Western sections of this range are used also by white-fronted geese, and between the Delta and Rockefeller refuges the winter range of the Canada goose is overlapped by that of the blue and snow geese.

In the coastal marshes are three principal concentration areas for Canada geese, figs. 39 and 45, and, as these vary somewhat as to type of habitat involved, each is discussed separately.

Delta of the Mississippi River.—

At the mouth of the Mississippi River, Canada geese are concentrated on the Delta National Wildlife Refuge and the adjacent area in the vicinity of Main Pass, *T* in figs. 39 and 45. Here they use a variety of marsh types, from the relatively hard deltaic flats bordering the Gulf Coast to the deep marsh—the “floating prairie” of the interior. This is the most isolated wintering area on the Louisiana section of the Gulf Coast. The marshes to the west between the Delta Refuge and White Lake, an air-line distance of 180 miles, are devoid of Canada geese, except for a small flock inhabiting Avery Island.

White Lake and Lacassine Refuge.—In the White Lake and Lacassine area, Canada geese occupy an extensive range (*U* in figs. 39 and 45): east to Cow Island, north to the edge of the prairie below Gueydan, west to Sweet Lake, and south to the Rockefeller Refuge, which lies below Pecan Island; the range does not include Grand Lake and Lake Misere. Within this area Canada geese are most abundant south of Gueydan, where prairie and marsh merge, and on the Lacassine Refuge. In the zone of contact between the prairie and the marsh, there are marginal rice fields and

wet pastures, interspersed with patches of maidencane, *Panicum hemitomon*, and southern wildrice, *Zizaniopsis miliacea*. A vast expanse of maidencane and Jamaica saw grass, *Mariscus jamaicensis*, with occasional low grassy ridges, is found throughout the marsh between White Lake and the edge of the prairie. At the west end of Pecan Island there are old stranded beach ridges roughly paralleling the coast line. The ridges, pastures, and rice fields are used extensively by geese for feeding areas. The deep marsh is used primarily for roosting.

Calcasieu Lake to Galveston Bay.

—The Canada geese occupying the range from Calcasieu Lake to Galveston Bay are found on Calcasieu and Sabine lake ridges, the edge of the prairie, and the relatively high sea-rim marshes from Johnson Bayou to Port Bolivar, Texas, (*Y* in figs. 39 and 45). The Louisiana section of this range is limited, consisting only of a narrow fringe around an extensive area of deep marsh. In Texas, however, the reverse is true: a wide area of sea-rim and prairie marshes around a relatively small area of deep marsh. Consequently, almost the entire Texas area is good Canada goose range. The marshes in this area, along with the high marshes of southwestern Louisiana, are heavily grazed by cattle, which keep the forage in an ideal condition for feeding geese. The geese frequently roost on the inshore waters of Calcasieu and Sabine lakes and Galveston Bay, as well as on such smaller water areas as Black and Brown lakes.

Inventory of goose habitat on the Gulf Coast in 1943–44 and 1944–45 revealed populations of 12,000 and 13,000 birds, respectively. Partial coverage of the Gulf Coast in 1945–46 indicated no significant change in numbers over the previous 2 years. The above figures represent great divergence from what was commonly believed to be the Canada goose population on the Gulf range. Vast areas of excellent marsh are unused by Canada geese. Alfred M. Bailey stated (personal communication) that, even in the late twenties, Canada geese could be found in only a few places on the Gulf Coast. The geese frequent these same places today.

“It has become scarcer of late years,” Bailey & Wright (1931) wrote several

years ago regarding the Canada goose population on the Gulf Coast. While there may have been much greater numbers of Canada geese wintering in the marshes of Louisiana 25 or more years ago, the decrease to present-day populations has not occurred altogether in recent years. It is more likely that the decrease was a gradual one, probably much of it caused by heavy shooting in northern parts of the range and in Louisiana. It seems altogether probable that at least some of the geese that normally would have wintered in Louisiana have been decoyed into Horseshoe Lake for entire seasons and have contributed to the annual kills there, but data are not available to show the extent to which hunting at Horseshoe Lake has affected Gulf Coast populations. For reasons discussed under "Autumn Migration Routes," it is difficult to believe that the kill made at Horseshoe Lake in any recent year would materially affect Louisiana populations the same year, for there are no data to show that an appreciable turnover in the population occurs at Horseshoe Lake within a single season.

In 1943-44, aerial coverage showed the following distribution of the Gulf Coast Canada goose populations: Delta Refuge 1 000, White Lake and Lacassine Refuge

7,000, Sabine Refuge (Gum Cove and Hackberry Island) 4,000.

GOOSE BEHAVIOR AND HUNTING LOSSES

The tremendous number of Canada geese bagged in the vicinity of Horseshoe Lake in recent years has made this area one of the most widely publicized shooting spots on the continent. The fearless and unwary behavior of the geese that winter at the Horseshoe Lake Game Refuge is responsible in large measure for the heavy kill, fig. 46. The response of this flock to hunting is contrary to the traditional reputed behavior of Canada geese. For centuries, the Canada goose has been extolled as one of the wisest and wariest of all birds and has been regarded as one of the most difficult to hunt successfully, but hunters and personnel engaged in wildlife management who have observed the habits of the Horseshoe Lake flock in Alexander County agree that these habits do not conform to the traditional pattern of Canada goose behavior.

How can the behavior of the Canada goose in Alexander County be reconciled with its traditional reputation? If the species is so wary or intelligent, why is it so unsuspicious and easily killed in Alexan-



Fig. 46.—A portion of the Horseshoe Lake Canada goose flock near the refuge headquarters. In many years, when food was scarce this flock lost much of its normal wariness.

der County? That the traits of the Horseshoe Lake flock are apparently singular cannot be denied, but there are many clues in the literature that help to explain its seemingly perplexing behavior. For example, many authors, after discussing the sagacity of the Canada goose, cite examples of the behavior of this goose that conflict with their previous remarks.

Grinnell (1901) has aptly expressed the enigmatic behavior of Canada geese: "The wild goose has long been proverbial for his shyness and wariness, and he well deserves the reputation that he has gained, and yet sometimes he is found to be 'as silly as a goose.' So that the gunner who follows the geese enough to see much of them will find that at one time great acuteness and at another a singular lack of suspicion are present in the ordinary wild goose. Few birds are more difficult to approach than these, and yet few come more readily to decoys or are more easily lured from their course by an imitation of their cry." A veteran goose hunter describes the Canada goose as "a bird of many moods. At times, very wise, but at other times very foolish" (Darby 1916).

Barnston (1862), referring to the Canada goose in the Hudson Bay region, writes: "Its disposition has less of wildness in it than that of the snow goose."

These citations and others given below show that many of the traits which make Canada geese vulnerable to hunting have been recognized elsewhere in the country, indicating that the behavior of the Horseshoe Lake flock is not as unique as one might be led to suspect. The unusual aspect of the reactions of the Horseshoe Lake geese seems to be that all or most of their behavior traits that tend to make them vulnerable to hunting are exhibited in the vicinity of Horseshoe Lake.

Wariness, Innate and Acquired

Many observers point out that geese are not so wary as various species of ducks, especially the mallard and black duck. Brandt (1943) noted a difference in wariness even in the newly hatched: "Young ducks of most kinds, just hatched, are very wild little creatures, which scatter at once and hide by all sorts of ruses. Newly hatched geese are most trusting little fellows."

The origins of the behavior differences between ducks and geese are deeply rooted. Lorenz (1937), Lack (1941), and Tinbergen (1942, 1948) have contributed to an understanding of these origins, which seem to relate in an important degree to the "innate perceptory patterns." There appears to be an inverse relationship between the specificity and specialization of these patterns and the degree to which the behavior patterns are (1) directed by "imprinting" (Lorenz 1937) during a brief period after hatching and are (2) developed, subsequent to the imprinting stage, by associative learning.

The acute wariness that adult geese normally possess seems to be mostly an acquired trait. Experience and association of the young geese with older birds appear to play an important role in the development of the traditional behavior pattern. If newly hatched goslings are taken before they have left the nest and are hand reared, their subsequent behavior shows considerable divergence from that of the wild birds. The readiness with which the Canada goose will become semidomesticated when given protection may possibly be related to the slow development of wariness in young birds.

A factor contributing to the fearless behavior of the Horseshoe Lake geese is the dual role played by man on and in the vicinity of the refuge. As the geese are accustomed to the sight of refuge workers, visitors, and the activities of a relatively dense rural population outside the refuge from the time they arrive in the autumn until the opening of the hunting season, they are apparently unable to comprehend the unfriendly role of the hunter. The same reaction to man has been found to be true in other places. Todd (1940) writes, "Under the protection now afforded at Erie Bay, the geese are less wary; on March 25, 1932, a party of which I was a member saw about twenty-five resting on the shore of a sheltered cove, and without apparent concern they permitted us to drive up in an automobile within one hundred feet."

Stone (1937) relates how Canada geese have responded to food and protection on the Atlantic Coast: "In season the farmers of this region [Cecilton, Maryland] go goose shooting on the

wheatfields and have decoy Canada geese to attract the wild birds. Of late years the ground has been baited and the geese return year after year to the places where they have been fed, which accounts for their abundance and tameness." (Notes from a field trip taken in February, 1927, when decoys and baiting were permitted.)

Even when Canada geese are wintering along the vast coastal marshes of the Gulf of Mexico, where, with an abundance of natural food, they might be expected to retain their independence, free-flying wild individuals will momentarily accept man at close range. At the Florence Club, near Gueydan, Louisiana, geese formerly used for decoys and tame cripples are brought into the club grounds for feeding each evening by calling and beating on a tin pan. On these occasions, numbers of wild geese accompany the tame birds into the club grounds and feed from the caretaker's hands. At all other times these same individuals seem to be unapproachable.

The importance of the role of man in conditioning the behavior of an entire flock was brought forcibly to our attention at the Miner Sanctuary. Until about 1925, wild Canada geese using the sanctuary were fed at a pond, 150 feet in diameter, which is located a few yards from the secondary road that passes in front of the Miner home. During the migration periods, when the geese were fed at this small pond, they were usually under the observation of large numbers of visitors, who, unconcealed, viewed them at close range. As a result of this encouraged familiarity, the vigilance of the geese toward man relaxed to such an extent that the local kills increased. Because the situation needed to be remedied, the geese were fed at a larger pond, fig. 40, away from the road, where they were hidden from public view by a dense grove of pine trees and a tight, 7-foot, wooden fence. Visitors who wanted to view the main concentration were required to use blinds or an observation tower overlooking the ponds. The resultant change in the behavior of the geese was profound, and local kills were soon reduced. After these new management measures were instituted, the sight of man was usually sufficient to flush the geese; previously,

they had to be practically driven out of the front pond before they would take flight.

Although the Canada goose possesses mental powers that at times seem to be superior to those of most birds, and that are undoubtedly of great survival value under primitive conditions, individuals appear unable to solve problems of self-preservation that arise in a highly modified environment such as that in the Horse-shoe Lake region. During the hunting season the geese wintering in that region exhibit almost a complete disregard for gunfire, flying back day after day to fields that often are the most heavily shot. This situation has perhaps been aggravated in recent years by the fact that the geese can feed in these same fields with impunity after the close of the day's shooting but are shot at on returning to feed the next day. The flock as a whole appears to be baffled by the presence of food and protection on the refuge at all times, and by the presence of food (standing corn, winter wheat) at all times but protection only a part of the time away from the refuge.

Family Grouping

Jenkins (1944), in a report on the social organization of a family of geese, states that "This well-integrated [Canada goose] family might be called a family supra-organism, since it performs the activities of a larger, more complex individual, through coordination of its components. This results in the dominance of the family, which is of survival value to its members in that they can feed first and rest in the center of the aggregation and are not pecked or chased."

Strong family ties in geese are undoubtedly of survival value against natural enemies, each family being a protective unit. Against man, during the hunting season, family grouping proves to be a liability, as the death or injury of one member frequently lures the rest of the family within gun range. Many a veteran goose hunter can cite examples of surviving members of a family flock, confused by the loss of one of its members, returning to a shooting pit to be shot at again. Bent (1925), in describing the duck-stand method of shooting geese on the inland ponds and lakes of Massa-

chusetts, writes, "When the geese are near enough and properly bunched a raking volley from a battery of guns is poured into them and other shots are fired as the survivors rise, with the result that very few are left to fly away. Even some of these may return and be shot at again if the leaders or parents of the young birds have been killed." This behavior trait has also been reported by Phillips (1916): "Now if a successful shot [probably meaning a series of shots fired at one time] is finally made into such a flock, and perhaps one half or three fourths of their number have been killed, the remainder, after a few turns in the air, or a short flight of five or ten minutes, will almost always return to the pond, where, if not actually disturbed, they will remain from several hours to a day or so. Sometimes they will decoy a second time."

The closely allied little cackling goose, *Branta minima*, sometimes exhibits the same type of behavior. "Even upon first arrival [in Alaska] many of the birds appear to be mated, as I have frequently shot one from a flock and seen a single bird leave its companions at once and come circling about, uttering loud call-notes. If the fallen bird is only wounded its mate will almost invariably join it, and frequently allow itself to be approached and shot without attempting to escape. In some instances I have known a bird thus bereaved of its partner to remain in the vicinity for two to three days, calling and circling about" (Nelson 1887).

Because of the concentration of birds at Horseshoe Lake, individuals from a broken family that return to the shooting fields in search of missing members can seldom be identified. However, one such instance was observed by a hunting club owner in 1944. Four geese from the refuge swung over a pit and two were dropped; the two remaining flew back toward the refuge, and when over the lake they made a wide swing and came directly back over the same pit, where they also were shot.

In 1945, another incident was noted that demonstrated the high vulnerability of the surviving members of a broken family. A flock of five geese entered a shooting field and, as the birds approached

the second pit, two of the flock were killed and one crippled. The two uninjured geese immediately alighted and remained with the cripple for about 10 minutes before taking flight toward the refuge lake. On their way to the lake, they were crippled, one being hit so severely it barely gained the refuge.

It is apparent from these examples of Canada goose behavior that the permanency of family ties offers one explanation why geese, unlike ducks, cannot easily be shot out of a field. Surviving members of broken families searching for mates, parents, or young that have been shot probably contribute appreciably to the total bag; thus, a high kill at a shooting club early in a hunting season may insure continuance of a high kill through the remainder of the season. The presence of the survivors over the shooting fields would tend to decoy unbroken families into gun range. As a result, the performance of the geese at some clubs toward the close of the hunting season might be aptly described as a perpetual-motion shooting gallery, the birds moving across the hunters' horizon in a never-ending procession against the heaviest kind of gunfire.

Sociability

The Canada goose is a social bird and, except during the breeding season, it tends to congregate in fairly large numbers. This tendency, which was common to some of our now extinct species of birds and mammals, often has two important undesirable results: first, under some conditions it causes the species to lose some of its normal wariness; and, second, when the remnants of a population band together they give an unwarranted impression of general abundance.

Audubon (1843) made the observation that the behavior of geese using small water areas may differ from that of flocks that resort to large bodies of water; that is, the behavior may vary according to relative densities on an area. "The Canada goose is less shy when met with far inland, than when on the sea-coast, and the smaller the ponds or lakes to which they resort, the more easy it is to approach them."

Apparently wariness is related both to the total size of an aggregation and its size in proportion to the area it uses. The first relationship may be of a psychological nature; many species of mammals and birds show a reduction in wariness when they are in large herds or flocks. It is fairly common knowledge that many species, for example the ruffed grouse, are very wild when at the bottom of their cycles but are quite readily killed when abundant. At Horseshoe Lake the wariness of the geese in the autumn decreases as the flock increases and spreads out over the refuge, thereby reducing the area of unoccupied ground to which disturbed flocks can retire.

While the loss of natural wariness in aggregations of wild game is serious from a long-term standpoint, the impression of abundance that local concentrations create in the minds of observers may serve as a fairly immediate threat to the future of a species since it becomes a premise for unlimited gun pressure. To substantiate this point we need only cite recent history of the flock at Horseshoe Lake. From 1942-43 to 1945-46 this flock had grown smaller each year, while most of the local residents and visiting hunters at Horseshoe Lake believed that each year there were "more than ever." To many hunters, a closed season on this flock in 1946 seemed to be a needless infringement of their privileges.

Hewitt (1921) has stated, "It should also be pointed out that when a formerly abundant animal becomes reduced in numbers the remnant may tend to herd together and thus give an impression locally of great abundance. . . . *Local* abundance, therefore, should never be taken as an indication of *general* abundance, and as a reason for permitting killing in large numbers."

Jackson (1943) has stressed the dangers of overshooting local remnants: "Extinction in every case was probably brought about at first by gradual depletion of the population and through local extirpation. When the population becomes reduced to a danger point, extinction may come with unexpected rapidity. Dislike the assertion as we may, in recent times the human species has been the prime factor in the extermination of other species."

HISTORY OF GOOSE HUNTING IN ILLINOIS

The hunting of Canada geese was once common in widely scattered areas over the state of Illinois. In most of the areas that formerly offered considerable shooting, the hunting of Canada geese as a sport of any consequence has ceased to exist. In a few, goose hunting has continued on a smaller scale; only in the Horseshoe Lake area has the kill in most years been high. Because the history of the sport in Illinois parallels the history of many other goose-shooting areas in the flyway, and because it relates to present goose-management problems, it is briefly reviewed here.

Two factors have been chiefly responsible for changes in the methods of goose hunting, and for the decrease or increase of goose hunting in different sectors: (1) the development of state, federal, and private refuges, frequently attended by artificial feeding, and (2) the outlawing of both baiting and use of live decoys. Formerly, fair bags of Canada geese were made on the Big Foot Prairie in the north-eastern portion of Illinois near the Wisconsin state line, but, with the establishment of a refuge and feeding station in southern Wisconsin, fewer birds have been available to northern Illinois hunters. The Putnam area, west of Lake Senachwine, in the Illinois River valley, yielded fair bags of geese until 1935, when both baiting and use of live decoys were prohibited. When feeding was curtailed, the area no longer proved attractive enough to hold flocks for sufficient time to provide hunting.

In about 1925, Mason County, bordering the Illinois River, was the most important goose-shooting area in Illinois. The use of live decoys in the fields of winter wheat situated near large bottom-land lakes was responsible for the popularity of this area. Field-pen hunting of Canada geese at private shooting clubs and at commercial day-shooting "clubs" in this county was centered largely east of Clear and Chautauqua lakes, northeast of Havana, and between Bath and Snicarte.

The average kill of honkers in the Clear Lake area in the twenties is reported to



Fig. 47.—Before paved roads and the Horseshoe Lake Game Refuge brought the hunter and the Canada goose into close proximity, goose hunting in southern Illinois was a fairly arduous undertaking. Here is a party of well-equipped hunters on their way to a Mississippi River bar. This photograph was taken in Alexander County in the early twenties. (Photograph by Bob Becker.)



Fig. 48.—Canada goose hunting as it was carried out on the Mississippi River sand bars in southern Illinois before the creation of a refuge at Horseshoe Lake. (Photograph by Bob Becker.)

have been about 100 per year or roughly 7 to 10 per cent of the number reported to have lingered in that area in those years. The top kill in the Bath-Snicarte area by the Brownstone Club in 1928 was 514 geese, more than the combined kill of all the other clubs in that region. In the late twenties and early thirties the average kill at Brownstone was about 400 per year. After the prohibition of baiting and use of live decoys, commercial day-

change in the type of wintering habitat, from one that was relatively primitive to one approaching parklike conditions, goose-hunting methods underwent an equally drastic change.

The following description is quoted from an unpublished report in 1941 by Arthur S. Hawkins, then of the Illinois Natural History Survey, and Paul S. Smith, then, as now, of the United States Fish and Wildlife Service.



Fig. 49.—Scene at goose-hunting club near Horseshoe Lake. The Horseshoe Lake region has been one of the most intensively hunted areas in the United States. The refuge totals only about 3,700 acres, but between 1941 and 1945 the area around it devoted to hunting averaged 11,000 acres controlled by an annual average of about 50 clubs. The number of pits and blinds in this acreage in the same period averaged approximately 400 and the total hunter capacity of the area 1,000.

shooting in the Illinois River valley was at an end, and only one private club primarily for goose shooting still exists. The continuance of Canada goose hunting in Mason County is due largely to the operation of two refuge areas, one private and one federal, that holds the birds in the area. In recent years, kills in the entire Illinois River valley have been about 400 birds per hunting season.

The river bars and islands of the Mississippi River between Chester and Cairo, Illinois, have been a wintering ground for Canada geese for many years, and since pioneer days this area has been noted for the goose shooting it afforded. The recent concentration of geese at Horseshoe Lake is in marked contrast to the wide dispersal of the birds in earlier times. With the

At the beginning of the present century there were comparatively few goose hunters, because goose hunting was no sport for the novice. Most of the hunters were skilled river men; those who traveled to the hunting grounds by land did so by horse- or mule-drawn vehicles over many tiresome miles of nearly impassable roads, fig. 47. Once at the shooting grounds there remained the task of digging a pit and placing the decoys, fig. 48. After a hard day's hunt, the hunter either camped out on a bare sand bar or faced a long return trip. Although there were more geese and fewer hunters in those early days, real skill was required to bag geese consistently because the goose range was extensive and the sand bars numerous.

Then, as now, silhouettes or "shadows," as they are called locally, were used to decoy the geese. Live decoys were seldom



Fig. 50.—Modern-day goose hunters in a typical pit at a day-shooting club adjacent to the Horseshoe Lake Game Refuge.



Fig. 51.—Typical goose blind in a soybean field near the Horseshoe Lake Game Refuge.

used until after 1906, when it became the custom to use three live decoys in combination with the silhouettes. The silhouettes were arranged in V-formation, with the apex of the V downwind from the pit. A live "caller" was placed at the vertex and at each end of the V. In between were the "shadows." Bait was not used, but, in order to induce the geese to work into the proper bar, hunters sometimes placed "scarecrows" on adjacent bars.

Improved roads and faster transportation brought goose hunting within the reach of the masses, fig. 49. Heavy competition for the better hunting places ensued. The demand for more hunting grounds resulted in the development of field shooting.

Long before baiting came into prominence, goose hunters recognized that no other type of feed was more attractive to geese than a large field of fall-planted wheat or rye. As soon as the weather turned cold, however, shelled and ear corn, wheat kernels, cowpeas, and similar feeds, when properly scattered, proved very attractive to the geese, although their desire for greens continued.

When decoys were used, the usual procedure was to construct a pen using a roll or two of 3-foot wire. In this pen were placed as high as 100 geese. Usually one or more geese were separated from their mates so that they would "talk" back and forth to each other. Another trick was to place a trained goose, which was wing-clipped, in the blind; the goose was then thrown from the blind and permitted to walk to the pen, "talking" to its mate in the pen as it went. If the first decoy failed to entice a wild flock within the range of the gunner, others were released from the pit until the wild geese decoyed as desired, or the supply of decoys was exhausted. Only a small percentage of captive geese behaved in such a manner as to make good decoys. These geese became as valuable an aid in goose hunting as well-trained bird dogs are in quail hunting, and commanded equally high prices on the market. The function of live decoys was to attract the geese, while that of feed was to hold them and to encourage the birds to return again.

One answer to increased hunting pressure was the formation of goose hunting

Table 10.—Goose hunting regulations as they applied to Alexander County, Illinois, 1927-1945.

YEAR	OPEN DATES (INCLUSIVE)	NUM- BER OF DAYS	TIME ¹	BAG LIMIT	POSSES- SION LIMIT	LIVE DECOYS	BAIT	MISCELLANEOUS
1927	10/1-1/15	106	<i>a</i>	8	None	Yes	Yes	
1928	9/16-12/31	106	<i>a</i>	8	None	Yes	Yes	
1929	9/24-1/7	106	<i>a</i>	8	None	Yes	Yes	
1930	9/24-1/7	106	<i>a</i>	4	8	Yes	Yes	
1931	11/1-11/30	30	<i>a</i>	4	8	Yes	Yes	
1932	10/16-12/15	60½	<i>a</i>	4	8	Yes	Yes	
1933	10/16-12/15	60½	<i>a</i>	4	8	25	Yes	
							by per- mit	
1934	10/6-1/13 ²	30	<i>b</i>	4	8	25	No	Duck stamp
1935	10/21-11/19	30	<i>c</i>	4	4	No	No	Duck stamp, 3-shell law
1936	11/1-11/30	30	<i>c</i>	4	4	No	No	Duck stamp, 3-shell law
1937	11/1-11/30	30	<i>c</i>	5	5	No	No	Duck stamp, 3-shell law
1938	10/15-11/28	45	<i>c</i>	5	10	No	No	Duck stamp, 3-shell law
1939	10/22-12/5	45	<i>c</i>	4	8	No	No	Duck stamp, 3-shell law
1940	10/16-12/14	60	<i>d</i>	3	6	No	No	Duck stamp, 3-shell law
1941	10/16-12/14	60	<i>c</i>	3	3 ³	No	No	Duck stamp, 3-shell law
1942	10/15-12/13	60	<i>e</i>	2	4	No	No	Duck stamp, 3-shell law
1943	10/15-12/13	60	<i>e</i>	2	4	No	No	Duck stamp, 3-shell law
1944	10/14-12/12 ⁴	60 ⁴	<i>f</i>	2	4	No	No	Duck stamp, 3-shell law
1945	11/24-12/31 ⁵	38 ⁵	<i>g</i>	2	4	No	No	Duck stamp, 3-shell law

¹ *a*—firing permitted; *a*—one-half hour before sunrise to sunset; *b*—sunrise to sunset, except that in 1934 on baited grounds closing time was 3 P.M.; *c*—7 A.M. to 4 P.M.; *d*—sunrise to 4 P.M.; *e*—sunrise to 12 noon; *f*—one-half hour before sunrise to 12 noon; *g*—12 noon to 4:30 P.M.

² Two days a week.

³ Three in any 7 consecutive days.

⁴ Or season limit of 6,000 geese (actually 21 days); by agreement of clubs, season began October 28 and was closed November 17. Information from V. C. Conover, Game Management Agent, United States Fish and Wildlife Service.

⁵ Or season limit of 5,000 geese (actually 5 days).

clubs, but since the time of the Egyptian Hunting and Fishing Club, organized in 1904, goose clubs have changed considerably in Alexander County. Present-day clubs, with a few exceptions, are strictly commercial. In contrast, this first club (which had annual dues of only \$5) was a nonprofit organization. At one time, it boasted a membership of 50, all local hunters. In 1941, there were at least two dozen clubs in Alexander County, each of which, according to a direct comparison of kill records, killed more geese annually than did the Egyptian Club.

Goose hunting first took on a commercial aspect when in 1913 a Chicago business man began to lease the sand bars most frequently used by the geese. By 1916, most of these bars were no longer open to public hunting. Up to that time field shooting had been scorned by most real goose hunters. Now that the river shooting was largely under the control of a few men it was field shooting or nothing for the old timers.

The purchase of Horseshoe Lake for a refuge in 1927 created a boom in commer-

cialization of goose shooting. Mediocre farm lands located near the refuge suddenly commanded fancy prices. Now almost every field located around the refuge contains pits and blinds during the hunting season, figs. 50 and 51.

Data obtained from veteran hunters on the number of geese killed along the Mississippi River in the eighties and later have been too contradictory to permit any definite conclusions. None of the information obtained, however, indicates that the kills made in those early years exceeded recent kills at Horseshoe Lake. A summary of hunting regulations as they applied to geese in Alexander County is given in table 10. The relationship between number of hours of open season, number of geese bagged, and hourly kill per season is shown in figs. 52 and 53.

Neither the hourly bag nor the seasonal bag shows significant correlation with the number of hours open to hunting.

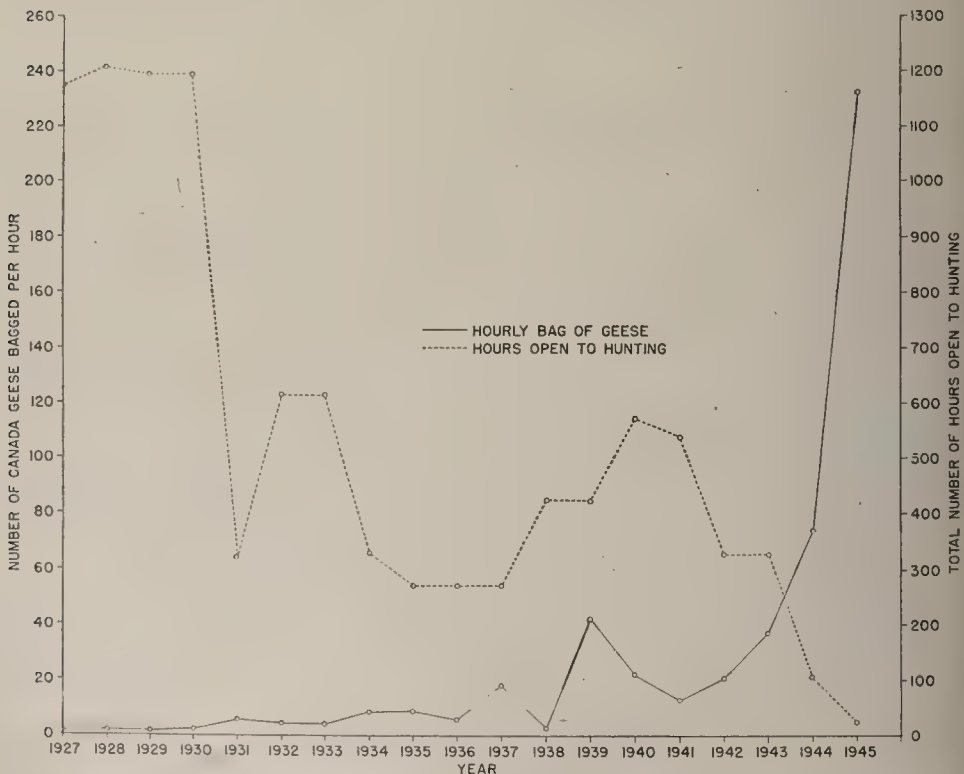


Fig. 52.—Hourly bag of Canada geese and number of hours open to hunting in Alexander County, Illinois, 1927–1945.

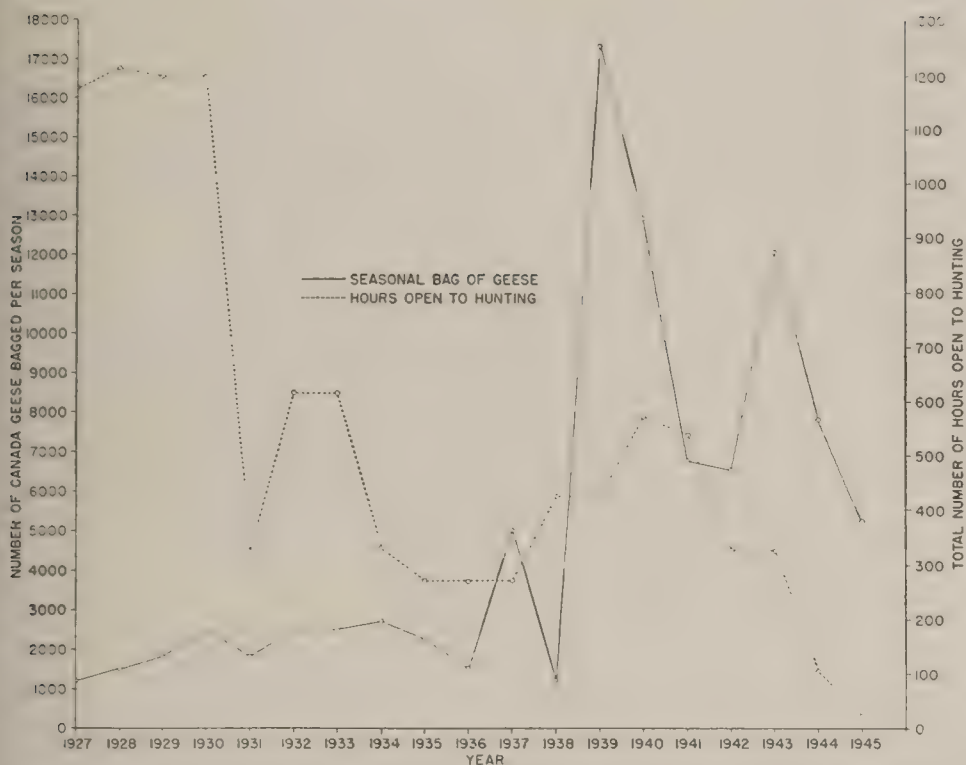


Fig. 53.—Seasonal bag of Canada geese and number of hours open to hunting in Alexander County, Illinois, 1927–1945.

ANNUAL BAG

In recent years the annual kill by hunters of Mississippi flyway Canada geese has probably exceeded losses resulting from any other single cause. The hunter kill includes the geese bagged and those so severely crippled by gunfire that they soon die.

Hochbaum (1944) has pointed out that the ratio of the number of hunters to ducks is such that it is mathematically possible for the licensed hunters legally to exterminate the continental duck population in one season. In the case of the Horseshoe Lake flock of Canada geese, the threat of extirpation has been real. If hunting in Alexander County, Illinois, had been permitted for the duration of the full 80-day waterfowl season either in 1944 or 1945, that population might have been reduced to a remnant, fig. 54.

Of all mortality factors, the bag by hunters is the one that can be most easily

controlled to insure preservation of the Canada goose population. Insofar as management of Mississippi flyway Canada geese is concerned, the annual bag has two subdivisions: the bag made by Indians on the breeding grounds in Canada, and the bag made by hunters in southern Canada and the United States while the geese are in migration or in the vicinity of the wintering areas.

On Breeding Grounds

Man is believed to be the predator taking the heaviest toll of Canada geese on the breeding grounds. Responsible for the bulk of the take in the James Bay area are the Cree Indians, natives of the region; the handful of white residents also kill a few geese. Food is the primary consideration for killing geese in the North; any sport involved only adds flavor to the undertaking.

In the James Bay and Hudson Bay area the native populations are dependent on

waterfowl as one of the few reliable sources of meat; big game animals are usually scarce and small game is subject to violent cyclic fluctuations in numbers. The importance of waterfowl, particularly geese, to the Cree Indians in former

no data regarding Churchill, but we conclude from Barnston's report that the white-fronted goose was shot in fair numbers by the Churchill Indians. It seems certain that snow geese and lesser Canada geese also contributed to the total kill in



Fig. 54.—The registered kill of Canada geese (1,400) on opening day at hunting clubs near Horseshoe Lake in 1945 was approximately equivalent to the number of geese shown in this illustration. (Photograph taken at the Horseshoe Lake Game Refuge by George W. Sommers.)

years can be readily realized from Barnston's report (1862). He estimated the annual kills of all species of geese on the west coast of James Bay and the south coast of Hudson Bay as follows: Moose Factory district, 10,000 annually; York Factory and Churchill district and region to the north, 10,000; Fort Albany district, 17,000 to 20,000 in the autumn and 10,000 in the spring; Fort Severn district, 10,000.

The species of geese that made up the bag at these posts must have varied considerably then as they do today. We have

that area. In recent years at Moose Factory, Fort Albany, Attawapiskat, figs. 55 and 56, and Weenusk, the annual kill of geese has consisted chiefly of blue geese and snow geese, with Canadas running a poor third. At Fort York, the annual kill of Richardson's geese, *Branta hutchinsii*, equals the combined kill of snow, blue, and Canada geese; the Canadas are outnumbered in the native hunter's bag at this post by the "wavies."

Big game represents an unpredictable source of food for the present-day Indian. In the early part of this century, caribou,



Fig. 55.—Attawapiskat, Ontario, summer, 1947. The Cree Indians of the James Bay region gather at such coastal posts as this soon after the breakup of the rivers in spring. In late summer or autumn they return to their inland trapping grounds. Those who trap far inland leave before the autumn hunt for blue geese and snow geese begins along the coastal marshes.



Fig. 56.—Summer scene at Attawapiskat. After a long winter of arduous trapping and hunting, often entailing considerable hardship, the native Indians are usually content to summer quietly at or near the coastal trading posts.

perhaps the barren-grounds type, migrated along the west coast of Hudson and James bays as far south as Fort Albany. They are now gone except for a small band at Cape Henrietta Maria, which may represent remnants of this migratory group. Woodland caribou are found scattered over the muskeg country in small bands, but their total numbers are not great.

When the long and dreary winter has fully expended itself, and the willow grouse (*Tetrao Saliceti*) have taken their departure for more northern regions, there is frequently a period of dread starvation to many of the natives, who are generally at that time moving from their wintering grounds to the trading posts. The first note, therefore, of the large gray or Canada goose (*Anser canadensis*) is listened to with



Fig. 57.—Through the establishment of a system of preserves and regulated trapping, beaver populations in the Hudson-James bay region are gradually being restored to former levels. Besides furnishing many pounds of highly nutritious meat and thereby reducing the hunting pressure by Indians on waterfowl, beavers also improve the character of small streams as brooding areas for Canada geese. This illustration shows a beaver dam on Little Partridge Creek, which empties into the southwest corner of James Bay. The tall trees that border the stream are black spruce; the principal shrubs are willow, alder, and sweet gale.

Moose, always quite abundant in the country just south of James Bay, were scarce in the muskeg belt lying west of the bay until 1946 and 1947, when there was an unprecedented influx of these animals, presumably from the south and west. On the whole, however, except for the waterfowl he kills in spring and autumn, the James Bay Indian must rely on small game, such as snowshoe hares, muskrats, grouse, and ptarmigan for his meat supply. When these cyclic species fail he is usually in dire straits. Barnston (1862) wrote:

a rapture known only to those who have endured great privations and gnawing hunger. The melancholy visages brighten, and the tents are filled with hope, to which joy soon succeeds, as the happy father, or the hopeful son and brother, returning successful from the hunt, throws down with satisfaction and pride the grateful load.

Although the economic plight of the Indian has been gradually improved from those early times, particularly in recent years, through Dominion government family allowance, government relief, and liberal credit at the fur posts, the first

arrival of geese in the spring is always an event of great importance. Bishop Robert J. Renison of the Diocese of Moosonee relates one of the highlights of his early years as Anglican minister at Fort Albany. A funeral service had just been held at the small church and the mourners, cold, sick, discouraged, and hungry after a long winter, were moving on snowshoes toward the cemetery (Renison 1944).

The Missionary walked in front, treading warily among the tents where husky dogs prowled, on his way to the little grave yard where two men with pickaxes had been for hours chipping the frozen earth deep enough to make a shallow trench. Although in the morning the whole scene looked and felt like the ragged end of winter, now the South wind grows warmer every moment and already the haze is seen in quivering waves over the melting ice and snow.

As the cortege was lost in the maze of wigwams, suddenly the cry of wild geese was heard. The funeral procession stood still and from all over the settlement came the answering call from every living soul. A great flock of Canada grey geese swept like a gigantic airplane over the trees rejoicing at what seemed a welcoming call. The phalanx turned to leeward and sailed slowly down over the spot from which the sounds came. It was too much even for sorrow and decorum. The Chief Mourner dived into his tent and appeared in a moment with his loaded gun. With incredible ease and grace he brought down a goose with each barrel. Cheers and laughter rang out. The oldest instinct of man triumphed in every simple heart and as the pallbearers patted the bereaved husband on the back, he modestly replied like a true sportsman, "She did it. I always had luck when she was with me." Then the spell was broken; the procession resumed its direction.

The recent increase of beaver through restocking and the establishment of beaver preserves on the west side of James Bay will, now that trapping is open, add thousands of pounds of highly nutritious meat to the Indian food resources, fig. 57. Since beaver and most of the Canada geese are secured in early spring, beaver restoration will materially reduce the annual toll of geese. This shift in hunting pressure is reported to have taken place in the Rupert House country where beaver trapping has recently been on a sustained-yield basis.

The spring kill of the Canada goose west of James Bay takes place inland when the Indians are still on their trapping grounds and the rivers are frozen over. Hunting is done from blinds or stands built of brush and set out on the



Fig. 58.—Decoys made by Cree Indians hunting in Hannah Bay at the south end of James Bay. The decoy in the top picture was made of willow twigs; the lifelike decoy in the lower picture was made from a log and a charred stick.

river ice. Decoys made of willow twigs or small stumps or blocks of wood of proper size are set up in such a way as to bear a crude resemblance to a flock of sitting geese, fig. 58. Often using inferior arms with hand-loaded shells, the native hunters easily overcome the handicaps of poor equipment by their expert ability to call geese, an art practiced from

childhood. In late summer, some of the Indians supplement their meager diet by hunting ducks along the coast, fig. 59, while in autumn most of the hunters are in the coastal marshes for blue geese and

native hunters with the aid of an interpreter, fig. 60. In some cases it appeared that the hunter questioned could remember his exact bag of the current year and of the previous year. In many other cases,



Fig. 59.—Indian encampment on Cape Henrietta Maria. The Indians of this group trade at the Lake River outpost, but visit Attawapiskat briefly in the summer. Before autumn, they return to the cape to hunt waterfowl.

snow geese, hoping to accumulate a supply of meat for at least a part of the winter. Any Canada geese killed at these times are incidental to the hunt for "wavies," as then the latter outnumber the Canadas along the coast by the ratio of many hundred to one.

Our bag data were secured from post managers and other informed residents and through direct questioning of the

it was equally obvious that the hunter could remember only the approximate number of geese killed and bagged, as he gave figures in multiples of 5 or 10. The inherent tendency to exaggerate in giving "rounded off" figures introduces considerable error. Therefore, we believe that the data in table 11 may exceed the actual bag by perhaps 10 to 15 per cent.

A few Indians, fortunate enough to



Fig. 60.—The number of Canada geese killed by Indians was calculated from information secured through personal interviews with native hunters. The hunter being questioned here, with the aid of an interpreter, is a member of the Ogoki band. Sixteen hunters of this band were interviewed in 1946 and the same number the following year. The total number of Cree hunters interviewed was 94 in 1946 and 171 in 1947.

Table 11.—Number of Cree Indian hunters, average bag per hunter, and total calculated bag of Canada geese by native hunters residing in the breeding range of the Mississippi Valley goose population, 1946 and 1947.

FUR TRADE POST AND INDIAN TRAPPING TERRITORY	TOTAL NUMBER OF HUNTERS	NUMBER OF HUNTERS INTERVIEWED		AVERAGE BAG PER HUNTER INTERVIEWED		CALCULATED BAG PER TRAPPING TERRITORY	
		1946	1947	1946	1947	1946	1947
Ogoki.....	16	16	16	3.0	3.6	48	56
Fort Albany (including Kapis- kau and Ghost River out- posts).....	100	24	67	9.5	11.1	950	1,110
Attawapiskat ¹ (including Lake River outpost and Akimiski Island).....	134	28	31	13.3	15.6	1,782	2,090
Weenusk.....	33	—	31	15.0 ²	19.0	495	627
Fort Severn.....	47	26	26	14.0	17.0	658	799
Total.....	330	94	171	65.0	66.3	3,933	4,682
Average.....				13.0	13.1	—	—

¹ The bag at Attawapiskat in 1948 was 1,720 according to Dr. John Honigman, resident anthropologist at the post that year (personal communication).

² An estimate, based on data for later year.

have their trapping grounds located in good Canada goose hunting territories, bag as many as 45 geese per hunter, while other Indians, located in poor goose habitat, take only a few geese or none. In 1944, when the inventory showed that there were approximately 66,000 geese in the Mississippi flyway, the estimated bag on the breeding grounds was 5,500, or about 8 per cent of the number of birds believed to have been available to the Indians in the spring of that year. In 1946 and 1947, the calculated bag, table 11, represented about 10 and 9 per cent, respectively, of the total population available in the springs of those years, table 7. Band recoveries, on the other hand,

indicate that the annual bag of the natives is about 5 to 6 per cent of the available population. Taking into consideration the kind of error inherent in these data, it would seem that the Indians do not kill more than 10 per cent of the Canada goose population that reaches the breeding grounds in the spring.

The time of kill of Canada geese by Indians on the breeding grounds is indicated in fig. 61.

Southern Canada and United States

Available data on the goose bag in the United States and in southern Canada are very unsatisfactory. Goose bag records from Illinois are more nearly complete

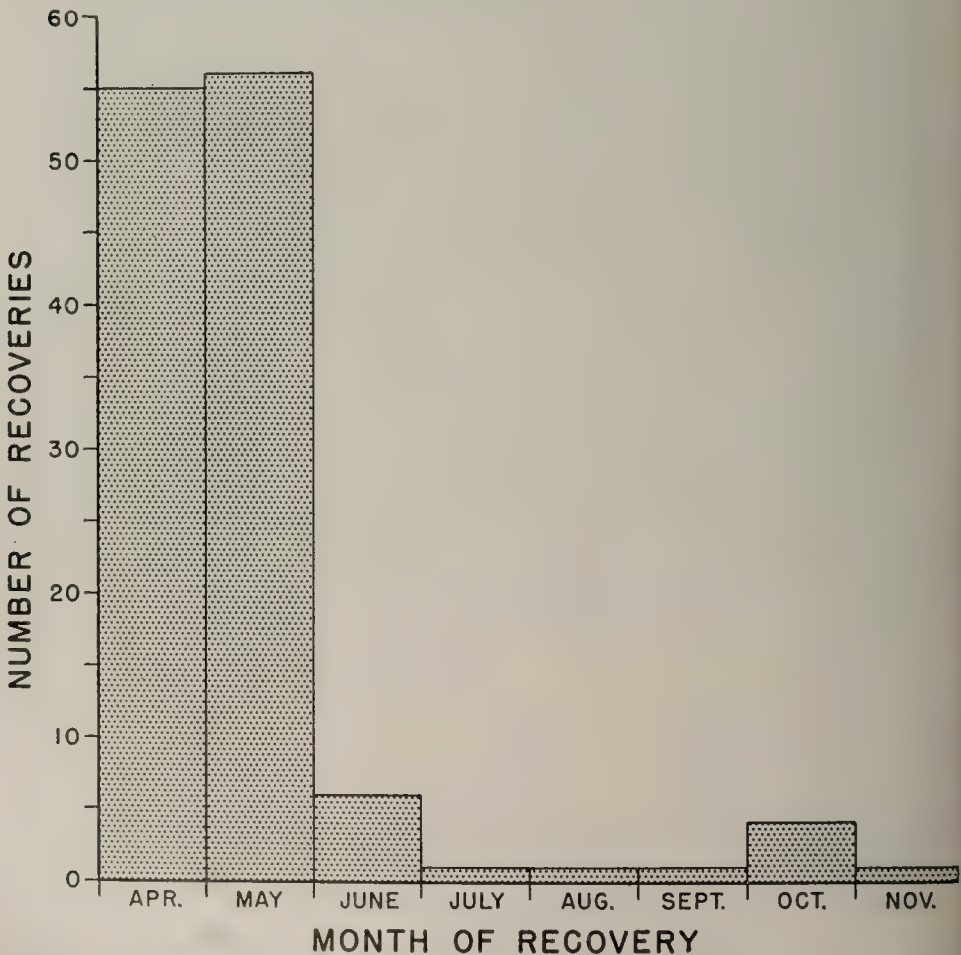


Fig. 61.—Time of kill of Canada geese by Indians on the breeding grounds, as shown by recovery records, 1941–1947, of geese banded at the Horseshoe Lake Game Refuge.

Table 12.—Estimated bag of Canada geese in regions frequented by the Mississippi Valley population, 1941-1945.

PROVINCE, STATE, OR OTHER AREA	LOW ANNUAL BAG	HIGH ANNUAL BAG	ESTIMATED MEAN BAG
West coast of James Bay.....	3,950	5,500	4,700
Ontario, exclusive of James Bay region.....	100	700	400
Minnesota.....	100	300	200
Wisconsin.....	450	850	620
Michigan.....	1,000	5,000	2,000
Indiana.....	1,000	2,000	1,500
Illinois.....	5,250	18,400	8,400
Ohio.....	?	?	200
Iowa.....	50	100	75
Missouri.....	150	400	260
Arkansas.....	200	400	300
Kentucky.....	25	100	50
Tennessee.....	50	150	100
Mississippi.....	50?	800	400
Louisiana (eastern part only).....	?	?	150
<i>Total</i>	<i>12,375</i>	<i>37,700</i>	<i>19,355</i>

than those from any other state, in part because of a law that requires all licensed clubs to keep daily records of their take and in part because only a small number of areas in the state afford goose hunting. Most states in the flyway, however, attempt to calculate the take, either from report cards attached to the hunting licenses (the cards are designed to be mailed to a state official at the end of the season) or from data obtained from questionnaires sent to a sample of the licensed hunters. A few states make no attempt to secure bag data.

Bag data based on the hunter-report-card system are apt to be exaggerated. Studies made by Bellrose (1947) have shown that the state-wide bag of ducks in Illinois calculated from report cards is several times the actual bag. In Wisconsin, the calculated bag of Canada geese for two counties has been from 3.5 to 4.6 times the actual bag (see section on Wisconsin, below). Furthermore, as many states do not record the goose bag by species, the actual portion of the calculated bag that consists of Canada geese can only be estimated.

Table 12 summarizes our information on the Canada goose bag in recent years in those regions that lie in the Mississippi flyway. A more detailed analysis of the bag follows.

Southern Ontario.—In spite of the fact that the Miner Sanctuary, at Kings-

ville, in Essex County, has been a heavy concentration point for Canada geese for over 20 years, no commercial shooting clubs have operated in the fields surrounding the sanctuary. All of the hunting in the Kingsville area is reported to be flight shooting from public roads as the geese go to and from the sanctuary and their roosting grounds on Lake Erie.

The number of banded geese reported taken in this area does not indicate the true size of the bag since some of the local shooters do not appreciate the importance of the banding program at the Miner Sanctuary and do not report the bands they recover.

When live decoys and baited fields were permitted, the autumn bag in Essex County was about 1,000 birds, but, since these practices were outlawed, the bag has probably not exceeded 500 and frequently is as low as 200 or 300 birds. We are informed that the 1945 kill was unusually low, not over 50 geese.

We are told that near the Miner Sanctuary it is possible to bag geese easily only on days when there is a heavy overcast and a strong wind is blowing, thus causing the geese to fly low. On most days the geese are reported to be well out of gun range when they pass over the hunters who shoot on the perimeter of the protected area, the radius of which extends 1 mile beyond the sanctuary property.

Table 13.—Recoveries in the Mississippi flyway,* 1925-1944, of Canada geese banded each autumn and winter at Kingsville, Ontario.

STATE	RECOVERIES BY 5-YEAR PERIODS								TOTAL	
	1925-1929		1930-1934		1935-1939		1940-1944			
	Num- ber of Recov- eries	Per Cent of Total Recov- eries	Num- ber of Recov- eries	Per Cent of Total Recov- eries	Num- ber of Recov- eries	Per Cent of Total Recov- eries	Num- ber of Recov- eries	Per Cent of Total Recov- eries	Num- ber of Recov- eries	Per Cent of Total Recov- eries
Michigan	8	8.4	36	13.0	30	18.6	57	19.5	131	15.9
Wisconsin	4	4.2	3	1.1	2	1.2	3	1.0	12	1.4
Minnesota	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Ohio	14	14.6	28	10.1	8	5.0	26	8.9	76	9.2
Indiana	13	13.5	15	5.4	9	5.6	28	9.6	65	7.9
Illinois	34	35.4	143	51.8	61	37.9	131	44.7	369	44.7
Iowa	0	0.0	0	0.0	1	0.6	1	0.3	2	0.2
Kentucky	8	8.3	23	8.3	15	9.3	11	3.8	57	6.9
Tennessee	7	7.3	12	4.4	13	8.1	13	4.4	45	5.4
Missouri	5	5.2	9	3.3	17	10.6	15	5.1	46	5.6
Mississippi	1	1.0	1	0.4	1	0.6	1	0.3	4	0.5
Arkansas	2	2.1	6	2.2	0	0.0	5	1.7	13	1.6
Louisiana	0	0.0	0	0.0	4	2.5	2	0.7	6	0.7
Total	96	100.0	276	100.0	161	100.0	293	100.0	826	100.0

* Recoveries made in central and eastern Ohio, Kentucky, and Tennessee would be at the expense of the Southeast population.

We have no data on bags elsewhere in Ontario, but recoveries indicate that relatively few geese are shot between James Bay and the Miner Sanctuary. According to Dr. C. H. D. Clarke of the Ontario Department of Mines and Resources, very little goose hunting is now carried out along the east shore of Lake Huron. Formerly the use of live decoys in this area provided fair shooting. The average annual bag of Mississippi flyway geese in southern and western Ontario is estimated to be about 400.

Illinois.—More Canada geese of the Mississippi flyway are bagged in Illinois than in any other state in the wintering grounds. Recoveries of Miner autumn-banded geese show 45 per cent from Illinois; recoveries of Horseshoe Lake bandings show 60 per cent from Illinois, tables 13 and 14.

Most of the geese bagged in Illinois are shot in the Illinois River valley and Alexander County; only a few geese are shot in other sections of the state. From a knowledge of kills at the principal goose-shooting clubs and from information gained through talks with sportsmen, Frank C. Bellrose of the

Illinois Natural History Survey placed the average annual bag in the period covered by this report at 1,100 birds for the Illinois River region and the rest of the

Table 14.—Recoveries within the wintering range of the Mississippi Valley population of Canada geese banded at Horseshoe Lake, 1940-41 through 1944-45.

STATE	NUMBER OF RECOVERIES*	PER CENT OF TOTAL
Michigan.....	20	8.9
Wisconsin.....	23	10.2
Minnesota.....	2	0.9
Ohio.....	2	0.9
Indiana.....	7	3.1
Illinois.....	135	60.0
Iowa.....	5	2.2
Kentucky.....	3	1.3
Tennessee.....	2	0.9
Missouri.....	14	6.2
Mississippi.....	2	0.9
Arkansas.....	1	0.5
Louisiana.....	9	4.0
Total.....	225	100.0

* Exclusive of recoveries the season of banding. Table also includes several recoveries for which exact locality data were unknown. Bands recovered in Missouri were in counties close to Horseshoe Lake and were probably from geese belonging to the Horseshoe Lake flock.

Table 15.—Annual shooting losses of Canada geese in the region of Horseshoe Lake, 1941-1945.

HUNTING SEASON	REPORTED BAG BY LICENSED CLUBS IN ALEXANDER COUNTY	ESTIMATED BAG ON NON-CLUB GROUNDS IN ALEXANDER COUNTY	BAG IN CAPE GIRARDEAU, SCOTT, AND MISSISSIPPI COUNTIES, MO.	TOTAL NUMBER OF GEESE BAGGED*	CRIPPLING LOSS AT 30 PER CENT OF TOTAL BAG	ESTIMATED ILLEGAL BAG	APPROXIMATE TOTAL LOSS
1927				1,200			
1928				1,500			
1929				1,800			
1930				2,500			
1931				1,800			
1932				2,500			
1933				2,500			
1934				2,700			
1935				2,250			
1936				1,500			
1937				5,000			
1938				1,200			
1939	17,300	?	?	17,300			
1940	12,900	?	?	12,900			
1941	6,524	100	150	6,774	2,032	150	8,956
1942	6,279	100	150	6,529	1,958	150	8,637
1943	11,162	600	300	12,062	3,618	300	15,980
1944	7,157	250	400	7,807	2,342	400	10,549
1945	4,444	500	300	5,244	1,573	300	7,117
Total				95,066			
Total last 5 years	35,566	1,550	1,300	38,416	11,523	1,300	51,239

* Bags for 1927-1938 estimated by Paul S. Smith from information gathered from club owners and others familiar with the area. Bags for 1939-1945 from club records.

state exclusive of the Horseshoe Lake area. The bag figures for the Horseshoe Lake area, which are much larger, are given in table 15. On days when the geese traded back and forth between the refuge and outside areas, particularly when the food supplies at the refuge were exhausted, most hunters having blinds or pits near the refuge secured their limits.

Michigan.—Michigan is probably second only to Illinois in its take of Canada geese of the Mississippi flyway. More bands from autumn-banded Miner geese were recovered in Michigan, 1925-1944, than in any other state except Illinois, table 13. Also, band recoveries indicate that, during the past 20 years, Michigan has harvested increasingly larger percentages of that portion of the Mississippi flyway population that migrates between the Kingsville, Ontario, region and Lake Michigan.

Although hunters in Michigan are required to report their annual bags of

geese, they are not asked to denote the species bagged. Consequently, the state-wide bags computed from hunter reports, table 16, include blue geese and snow geese, as well as Canada geese. Except for years when blues and snows linger on their flight south, Canada geese represent about two-thirds of the yearly kills, ac-

Table 16.—State-wide bag of all species of geese in Michigan, as calculated from hunter reports, 1938-1945. Data furnished by the Michigan Department of Conservation.

YEAR	CALCULATED BAG
1938	3,902
1939	6,635
1940	5,296
1941	5,921
1942	2,899
1943	6,567
1944	7,220
1945	23,129

cording to H. J. Miller of the Michigan Department of Conservation.

The figures given in table 16 are not comparable from year to year, because between 1938 and 1944 the number of licensed hunters sending in bag reports to the Department of Conservation dropped from 65 to 20 per cent. Because successful hunters are more apt to turn in their report cards than unsuccessful hunters, the accuracy of the computed kill varies from year to year. Excluding from table 16 the probable bag of blue geese and snow geese and taking into consideration exaggeration inherent in calculating statewide bags from hunter report cards, we estimate that the annual kill of Canada geese in Michigan from 1938 through 1944 was between 1,000 and 3,000 birds. In 1945, the total calculated bag of all species of geese was more than 23,000. Of this number, well over half consisted of blue geese and snow geese (Dr. Miles D. Pirnie of Michigan State College, personal communication) that failed to make their usual rapid southward migration and that were observed and shot in unusual numbers. The large number of banded geese reported shot in Michigan in the autumn of 1945 does, however, furnish undeniable evidence that there was a large increase in the total bag of Canada geese in that year over the number bagged between 1938 and 1944. Of 20 Canada geese banded at Horseshoe Lake between 1940-41 and 1944-45 and bagged in Michigan, table 14, 13 were bagged in the autumn of 1945.

The following Michigan counties, which are in the vicinity of important autumn concentration points and wintering areas, yielded the largest bags of geese of all species: Chippewa County in the northern peninsula; Leelanau County in the northwest sector of the lower peninsula; Huron, Tuscola, and Bay counties bordering Saginaw Bay; and Allegan, Kalamazoo, Barry, Berrien, and Calhoun counties in the southwestern lake section. According to Dr. Miles D. Pirnie of Michigan State College (personal communication in 1945) between 500 and 1,000 Canada geese were bagged within a 20-mile radius of the W. K. Kellogg Refuge, Barry and Kalamazoo counties, in 1944.

Various counties represented by 159 banded Canada geese shot in Michigan, 1925-1944, are shown in table 17.

Table 17.—Recoveries of Canada geese in Michigan, 1925-1944, banded at Horseshoe Lake, Illinois, and at the Jack Miner Bird Sanctuary, Kingsville, Ontario.

COUNTY	NUMBER OF RE- COVERIES	COUNTY	NUMBER OF RE- COVERIES
Allegan.....	31	Presque Isle...	2
Berrien.....	16	Alpena.....	2
Barry.....	13	Benzie.....	2
Huron.....	12	Lenawee.....	1
Kalamazoo...	12	Livingston... 1	
Calhoun....	11	Otsego.....	1
Sanilac.....	10	Gratiot.....	1
Monroe.....	5	Gladwin.....	1
St. Joseph... 5		Grand Traverse 1	
Van Buren... 4		Saginaw.....	1
Chippewa... 4		Roscommon... 1	
St. Clair.... 4		Luce.....	1
Mackinac... 3		Kent.....	1
Cass.....	3	Oscoda.....	1
Washtenaw.. 2		Lapeer.....	1
Wayne.....	2	Eaton.....	1
Newaygo.... 2		Lake.....	1
<i>Total recoveries.....</i>			<i>159</i>

Whatever the actual bag of Canada geese is in a given year in Michigan, it probably is not all at the expense of the Mississippi flyway population, as some geese belonging to the Southeast population undoubtedly are bagged as they migrate down the eastern edge of the state.

Wisconsin.—Band recoveries, table 14, indicate that Wisconsin is second only to Illinois in the toll its hunters take of the Horseshoe Lake flock. The largest kills of Canada geese in Wisconsin are made in Rock and Walworth counties, in the vicinity of the Rock County Refuge.

Geese in the Rock-Walworth county area show little of the tameness exhibited by the Horseshoe Lake flock. On leaving the refuge on the upland prairie for their roost lakes, they are said generally to spiral high up out of gun range before crossing over its boundaries, thus accounting in part for the relatively small kill, which is equivalent to about 8 per cent of the geese that are present in these two counties in late autumn and winter.

Careful estimates of annual bags in the Rock County Refuge area by personnel of the Wisconsin Conservation Department and the United States Fish and Wildlife Service, 1940-1945, did not exceed 400 birds; the average annual bag was considerably less. Wisconsin Conservation Department estimates for the probable and maximum Canada goose bags in these counties are as follows:

1940-200

1941-75, not exceeding 150

1942-317, not exceeding 400

1943-150, not exceeding 200

1944-40, not exceeding 50

1945-350, not exceeding 400

When the above estimates are compared with the bags calculated from hunters' report cards (1940, 732; 1941, 581; 1942, 1,445; 1943, 629), it appears that the annual calculated bags are exaggerated 3.5 to 4.6 times. These calculated bags are derived from a sample of the kill cards sent in by about 35 per cent of the licensed hunters. If the calculated state-wide bags reported by the Wisconsin Conservation Department are exaggerated to the same degree as are bags for Rock and Walworth counties (3.5 times), the corrected state-wide annual bag of Canada geese in Wisconsin between 1932 and 1944 has averaged about 500 birds and varied from about 170 (1935) to 860 (1942). If our method of estimating the state-wide bag is sound, it appears that the annual kill of Canada geese in Wisconsin has seldom approached the thousand mark.

Important kills have also been reported for Waushara County. The bag in this county in 1942 was estimated by Zimmerman (1942) to be 400. The total number of migrant geese that offered shooting to hunters in this area is unknown.

Minnesota.—Most of the Canada goose hunting in Minnesota is said to occur in the western third of the state, especially during the wet years. Kills in the eastern sections rarely occur, so that the total bag of the Mississippi flyway geese in Minnesota is probably small. The lack of band recoveries from eastern Minnesota substantiates this belief. From 1935 through 1944, the computed state-wide bags of all species of geese, based on reports received from 10 per cent of the

hunters, ranged from 1,869 to 5,050 birds. As in Michigan, the 1945 calculated bag, for all geese was the largest on record, 10,908.

Ohio.—We have few kill data for Ohio other than band recoveries. The principal kills of importance to Mississippi flyway geese would be those made in the region of Lake St. Marys. Kills made in central and eastern Ohio would be primarily at the expense of the Southeast flyway geese. We have arbitrarily placed the bag of Mississippi flyway Canada geese in Ohio at 200 per annum.

Indiana.—According to William B. Barnes of the Indiana Department of Conservation, goose hunting in Indiana is heaviest in the Kankakee region of northwestern Indiana and in the lake district to the east. As the flights move through northern Indiana to the southwest, additional shooting is provided in the Wabash River valley. Hunting pressure in this state appears to be, on the whole, relatively moderate. Of the total number of recoveries of geese banded at the Miner Sanctuary during the autumn in the past 20 years, approximately 8 per cent have been from Indiana, table 13.

At Hovey Lake Refuge about 300 Canada geese are generally present during the open hunting period, and the largest bag in any one season in a 5-year period, 1940-1944, was only five birds, 1.6 per cent of the flock. Partly responsible for this small bag was the wildness exhibited by the geese in the refuge vicinity.

Judging from questionnaire answers received from hunters by the Indiana Department of Conservation, it is doubtful if the kill of Canada geese in Indiana in recent years has ever greatly exceeded 2,000 birds and probably in most years the kill is considerably less than this figure.

Iowa.—According to Bruce F. Stiles of the Iowa State Conservation Commission, the yearly kill of Canada geese in Iowa is about 1,200 birds. He states that the heaviest migration is down the Missouri River valley. As band recoveries indicate that central and western Iowa is well west of the migration routes of the Mississippi flyway population, only a small portion of the above kill would be at the expense of this population. The paucity of band recoveries from eastern Iowa,

tables 13 and 14 and figs. 13-21, signifies that few Mississippi flyway geese migrating through this sector of the state stop en route long enough to afford much shooting.

Missouri.—The Missouri Conservation Commission estimates that, prior to the establishment of the Horseshoe Lake Game Refuge, approximately 75,000 Canada geese wintered on the sand bars and islands of the Mississippi River between Ste. Genevieve and Caruthersville, Missouri. Band recoveries, table 13, with the exception of returns from 1935 through 1939, indicate no pronounced change in the Missouri kills in relation to the Illinois kills since 1925. Before 1941, when the geese using the Horseshoe Lake Game Refuge were reported to have made daily flights to the river bars, considerably larger kills are said to have been made in Cape Girardeau, Scott, and Mississippi counties than in more recent years. Band-recovery data indicate that this period of higher kills was between 1935 and 1939. The yearly bags, estimated for the above counties by Paul S. Smith, are given in table 15. According to information received from M. O. Steen of the Missouri Conservation Commission, the annual bags in Missouri in the region of Cape Girardeau, Scott, and Mississippi counties averaged approximately 175 geese in recent hunting years.

State-wide annual bags, 1943-1945, are estimated to have been less than 400 birds. Besides the bag in southeastern Missouri, about 125 geese were killed on the Missouri River between Booneville and Jefferson City in central Missouri, and approximately 100 were killed in the vicinity of Swan Lake National Refuge in the north central part of the state. However, on the basis of present evidence, it would appear that the geese killed in central Missouri belong to the Eastern Prairie population and are not Mississippi flyway birds. Considerable numbers of Canada geese are reported to migrate through central and southwestern Missouri in the autumn, and it seems reasonable to conclude that they winter in western Louisiana and eastern Texas.

Kentucky.—Little information is available in regard to the state-wide kill in Kentucky, though band recoveries indi-

cate that only the kills made in the western portion of the state would be from the Mississippi Valley population. Band recoveries show that since 1940 the annual bag of Mississippi Valley geese in this state has been greatly reduced, table 13. In 1939 and 1940, Paul S. Smith estimated that about 100 geese from the Horseshoe Lake flock were bagged in Kentucky; in more recent years, band recoveries and the findings of reliable observers indicate that very few geese from the Horseshoe Lake flock have been shot in Kentucky.

Tennessee and Mississippi.—The section of the Mississippi River bordering Tennessee, Arkansas, and Mississippi may be considered as a single unit insofar as the kill of Canada geese using the river bars is concerned. In 1943, it was estimated that not over 50 geese were killed on and in the vicinity of the Tennessee section. It is the belief of W. F. Dearman, formerly director of the Mississippi Department of Fish and Game, that the 1943 bag for his state along the Mississippi River was approximately 800.

Arkansas.—Kills of Canada geese in eastern Arkansas, exclusive of the Mississippi River, are made over such an extensive area and in such relatively small numbers in any given locality that it is difficult to make an accurate appraisal of the over-all loss. In 1943, the bag was about 400, and in 1945 it was probably even lower. After talking with hunters, employees of hunting clubs, and employees of local cold-storage plants, we concluded that the bag of Canada geese in the Stuttgart region in 1945 did not exceed 200.

Louisiana.—In 1943, losses of Canada geese through hunting in the delta and coastal marshes were estimated to be approximately 1,000. Of this number about 150 were estimated to be Mississippi flyway geese; the greater portion of the Canada goose population in Louisiana is in the western portion of the state and probably belongs to the Eastern Prairie population.

Total Annual Bag

Before sound management measures can be instituted for the Mississippi Valley Canada geese, the over-all kill in the population must be known within

fairly close limits. We do not have complete data on the kill, but a reasonably accurate appraisal can be made from available information.

Table 12, summarizing bag data contained in previous discussions, is fairly accurate in some instances and in others represents very rough estimation. It should be remembered that the lowest and highest bags for the various areas represented did not occur in the same calendar year; hence, totals for those respective columns do not represent annual extremes. It would appear from table 12 that the average annual bag in the flyway, 1941-1945, was somewhere in the neighborhood of 19,000 birds.

The annual loss of geese through hunting, expressed as a percentage of the population that left the breeding grounds in the autumn, may be roughly estimated* for the Horseshoe Lake flock and the flyway population as a whole.

The number of geese calculated to escape death from natural causes after leaving the breeding grounds and to be subjected to hunters' guns may be arrived at by adding known hunting losses to inventory figures after the hunting season. For example, the Horseshoe Lake flock numbered about 37,000 geese at the time of the 1943-44 inventory, table 9. Local losses in the Horseshoe Lake area, including crippling, were approximately 16,000 geese, table 9. Assuming that losses between the Canadian border and Horseshoe Lake were average that year, an additional 3,250 geese (2,600, a figure based on band recoveries, plus an assumed 25 per cent crippling rate) were lost.

The autumn kill by the Indians on the breeding grounds is small, fig. 61, as is also the kill by white hunters in southern Canada. Including crippling losses of 25 per cent, the combined kill may be in the neighborhood of 800 birds, about half of which would be contributed by potential Horseshoe Lake geese. Of the 37,000 geese leaving Horseshoe Lake in the spring, approximately 8 per cent are bagged by the natives plus an estimated additional 2 per cent lost through crippling, or a total of 3,700 geese lost. The

estimated combined total of all hunting losses for 1943-44 was 23,350.

Inventory figures plus hunting losses for 1943-44 (omitting the spring Indian kill which occurs after the inventory) indicate that the Horseshoe Lake population that left the breeding grounds in the autumn of 1943, and subsequently eluded death from other causes during the following 6 to 8 months' period, was roughly 56,650. Thus, total losses through hunting (including spring losses in Canada) are computed to have been about 41 per cent of the geese that survived death from natural causes. When crippling losses are deducted, it appears that hunters bagged about 30 per cent of the geese that survived death from natural causes.

Over-all loss rates due to hunting for 1944-45 and 1945-46, calculated in a similar manner, were approximately 39 and 40 per cent, respectively, of the population that survived other types of mortality.

Hunting losses for the flyway population as a whole, as might be expected, were at a considerably lower rate than for the Horseshoe Lake flock. In some recent years, the bag of geese in the flyway has been about 19,000, table 12. In some of the same years, inventory figures, table 7, indicate an average population of approximately 60,000. If the bag prior to inventory (roughly 14,600) and the overall crippling, arbitrarily placed at 25 per cent (total 18,250), are added to the approximately 60,000 surviving at inventory, an original population of 78,250 is indicated. Thus, of all flyway geese that survived natural mortality during recent hunting periods, at least 23 per cent are estimated to have succumbed to hunters.

Canada vs. United States Kill

Are the people of Canada, especially the Indians and Eskimos, getting an unjustifiably large share of the Mississippi flyway Canada goose population? Many hunters in the United States would like to believe that such is the case. However, investigators (Soper 1930, Sutton 1932, Brandt 1943, Gillham 1948) of bird life in the far north believe that in most instances the future of waterfowl populations in arctic and subarctic regions is not threatened by the kills made by the native

* Accuracy of the following estimations is in large measure dependent on the accuracy of inventory figures used in the computations.

peoples. It is their belief that the fate of waterfowl populations breeding in the north will be decided by the treatment accorded them on their wintering grounds. We likewise believe that the future of the Mississippi Valley population is dependent on the protection and care it is given south of the breeding range.

On the breeding grounds of the Mississippi Valley Canada geese, there has been a decrease, in recent years, in the number of Indians dependent upon the game resources of the country. After World War I, many of the Fort Albany Indians moved to new trapping grounds far into the interior. According to Dr. T. J. Orford, formerly Indian agent at Moose Factory, in 1945 there were 124 Indians from the Fort Albany band at Lac Seul, a locality to which they had moved in the 1920's. There was another exodus of Fort Albany Indians from the James Bay area in 1942 when 150 transferred to the Constance Lake band on the Canadian National Railway line. Additional Indian families moved down to Moosonee from Fort Albany and Attawapiskat during the years of World War II. As a result of these movements, Indian hunting pressure on wildlife in the James Bay area has decreased. In contrast, the number of hunters shooting Canada geese in the United States, notably in Illinois, has increased tremendously since World War I.

Data in table 12 show that the take in Canada, 1941-1945, was roughly 25 per cent of the total bag of Mississippi Valley geese. When it is remembered that the Indians are partly dependent on geese for survival, that their kill is not a new drain on the goose population, and that in recent years the kill has been found to be proportional to the goose population, this kill cannot be considered excessive.

The relative kill by the Indians and by hunters outside the breeding grounds in Canada and in the United States can be found by comparing the number of geese killed by each group to the total number of birds available to each. It was shown earlier that the Indians kill about 10 per cent or less of the goose population available to them. As the kill in Canada away from the breeding grounds is estimated as not exceeding 1 or 2 per cent of the population, the total Canadian kill is

concluded to be 10 to 12 per cent of the population available in any year.

A rough measure of the bag contributed by the flock between the Canadian border and the Horseshoe Lake Game Refuge can be derived from an analysis of band recoveries. Between 1941 and 1944, the number of band recoveries from north of the refuge was equivalent to 33 per cent of the number of recoveries in the region of Horseshoe Lake 1 or more years after banding. The number of geese to terminate their migrations at Horseshoe Lake, 1941-1944, averaged about 45,000. The known bag by licensed clubs in Alexander County in those years averaged 7,780, table 15. Figures based on estimates from band recoveries in 1941-1944 indicate that the flock contributed an average yearly bag of about 2,600 birds before reaching the refuge, or a loss of about 5 to 6 per cent of the numbers that crossed the Canadian border. As the Horseshoe Lake flock in recent years has comprised about 50 per cent of the Mississippi flyway population, the bag of Horseshoe Lake geese (2,600) computed from band recoveries for areas between the Canadian border and the refuge should, if doubled (5,200),* approximately equal the bag of all Mississippi flyway geese in the same area. Calculations from data in table 12 indicate that the estimated mean annual bag for states in the flyway north of Horseshoe Lake (Minnesota, Wisconsin, Michigan, Ohio, Indiana, Illinois,† and Iowa) for 1941-1945 is 5,695, a figure close to the bag figure approximated from band recoveries and from inventory figures and bag data from the Horseshoe Lake area. A check of band-recovery records for the period 1925-1944 shows that most geese bagged in this area were killed in November, fig. 62.

In the fall of 1943, when hunters between the Horseshoe Lake region and the Canadian border bagged between 5 and 6 per cent of the Mississippi flyway geese

* This figure, based on a comparison of band-recovery rates, may be low for two reasons: (1) the percentage of hunters reporting bands they recover is probably lower over most of the flyway than it is at Horseshoe Lake, where the importance of reporting bands has been well publicized, and (2) the geese that spend the greater part of the hunting season north of the refuge are subject to heavier shooting pressure in that region than are the Horseshoe Lake geese in the short time they are there.

† The figure for Illinois (about 1,100) does not include the bag for the Horseshoe Lake area.

available to them, hunters in the region of Horseshoe Lake bagged 23 per cent of the total number of geese attaining the refuge in the fall and winter of 1943-44. Figures for the Horseshoe Lake region, as calculated from data in tables 9 and 15, are 23 per cent for 1943-44, 19 per cent for 1944-45, and 18 per cent for 1945-46.

It is desirable at this point to discuss a type of rumor at times common among waterfowl hunters. During the 1944 hunting season, several hunters at Horseshoe Lake expressed the opinion that, if the ducks and geese needed further protection, the Indians in Canada should be prohibited from gathering and selling duck and goose eggs to a company manufacturing pancake flour. That this kind of complaint is an old story and has no basis in fact was shown by Grinnell (1901).

Various explanations of the change [waterfowl decrease] are given. The blame is laid on the market shooter, on the supposed destruction of birds and eggs on the northern breeding grounds, and on supposed changes in the lines of flight by migrating birds, but most gunners are unwilling to accept the logic of events and to acknowledge that the principal cause of the lessened number of the fowl lies with the gunners themselves, and is an inevitable accompaniment of civilization, not to be changed except by radical measures. . . .

One of the most grotesquely fantastic explanations of the scarcity of wildfowl was put forth several years ago in the newspapers: . . . This story told of an enormous destruction of wildfowl eggs in the Northwest for commercial purposes; millions of shiploads and trainloads of such eggs, it was gravely related, being annually gathered in Alaska and British America, and shipped

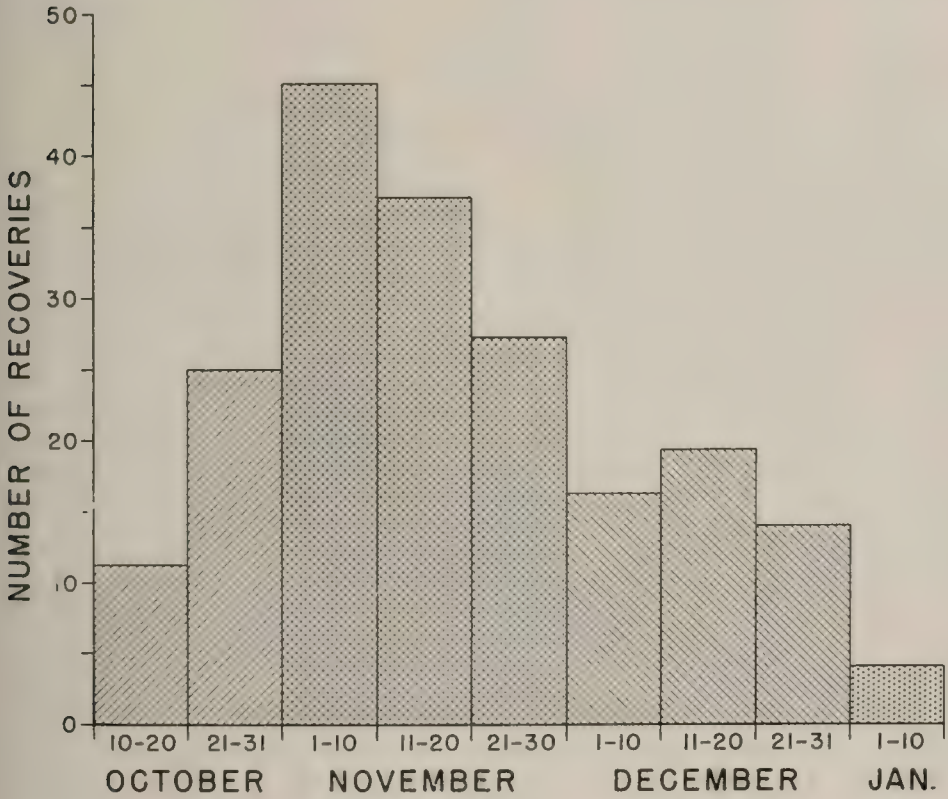


Fig. 62.—Time of kill of Canada geese in Wisconsin, Michigan, and Indiana, as shown by recovery records of Canada geese banded at the Horseshoe Lake Game Refuge and the Jack Miner Bird Sanctuary and recovered in the period 1925-1944. Migration dates and the time of most hunting seasons combined to make November the month of heaviest kill.

thence to points in the East, where they were manufactured into egg albumen cake. . . .

This, then, was the conclusion of the whole matter: Those who professed to have information on the subject were unable to substantiate the stories which they told; the transportation companies have carried no such eggs; none have ever been received at the ports of entry; the albumen trade knows nothing whatever about them, and in view of the total lack of evidence to support the story, there is no doubt that it is a pure invention.

DIFFERENTIAL HUNTING LOSSES

To manage a wildlife species that is subjected each year to heavy gun pressure, it is important to know not only how many individuals of a population are shot

annually, but also if the kill in each of the various age and sex groups is proportional to its size in the group, and if the kill places an undue burden on any particular component. One of the causes of concern relative to Canada goose shooting at Horseshoe Lake in recent years has been the disproportionately large kill of juvenile birds, table 23.

What are the underlying factors responsible for a differentially heavier kill of the younger geese? One factor has already been mentioned, namely, the strong bonds existing between members of family units. Related factors are the fearlessness of young geese and their dependence on adults for guidance during their first year of life.

The relationship of juvenile age to unwariness behavior in Canada geese was in-

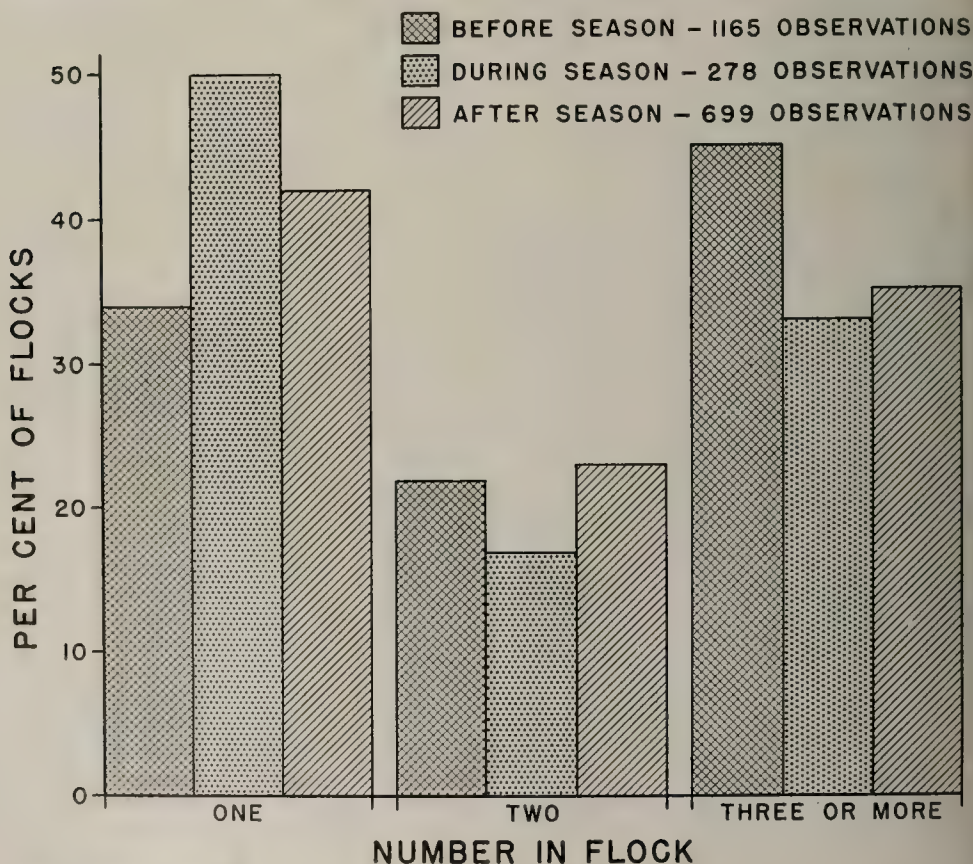


Fig. 63.—Percentages of each of three size-groups (single bird, pair, group of three or more geese) in the total number of flock formations of Canada geese observed before the season, during the season, and after the season at Horseshoe Lake, 1945.

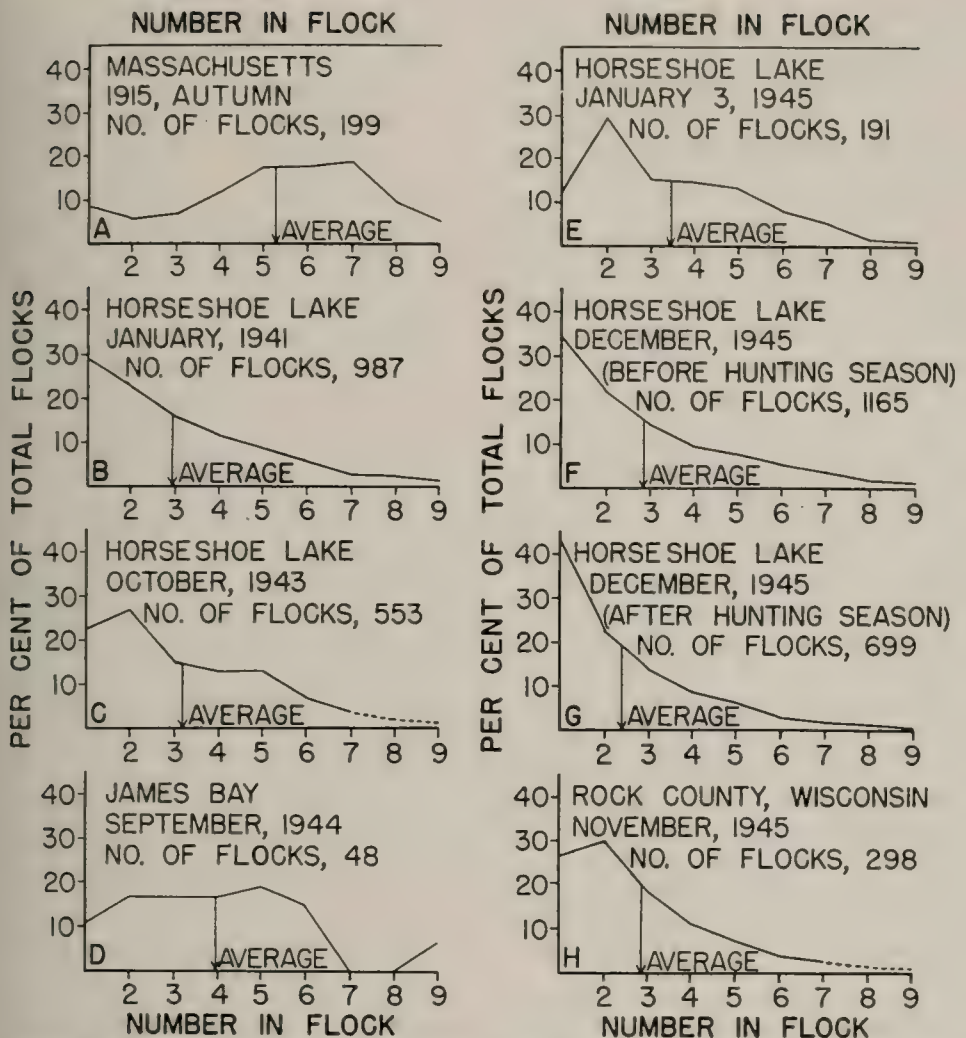


Fig. 64.—Frequency counts of flocks numbering nine or fewer geese and the average size of Canada goose flocks at four different locations.

timated by Phillips (1921). "It was remarked by Massachusetts gunners that there seemed to be a large proportion of young geese, and the same was true of Currituck Sound, N. C., where geese also appeared in unusual numbers and were very tame. The tameness of the geese in Massachusetts this past season caused comment everywhere, and I saw instances of it myself."

At Horseshoe Lake it was found that, as the shooting season progressed, the relative number of single birds increased because of the breaking up of family units,

figs. 63 and 64F, G. Single juvenile birds separated from their families were frequently observed to associate and feed with other family units, as well as with unattached adults, but they were often at the bottom of the peck order, and, as they never appeared to be accepted into the ranks of other families, they often flew alone.

Every veteran goose hunter knows that single birds are "suckers," more readily decoyed than pairs or flocks. During the 1945 season, Arthur S. Hawkins, then with the Natural History Survey, and the

Table 18.—Number of Canada geese shot and size of flock from which they came. Observations at Horseshoe Lake in 1945.

NUMBER IN FLOCK CONTRIBUTING TO KILL	NUMBER SHOT FROM FLOCKS		TOTAL INDIVIDUALS SHOT	PER CENT OF TOTAL INDIVIDUALS
	One	Two or More		
One.....	139	—	139	50.0
Two.....	33	15	48	17.3
Three or more...	75	16	91	32.7
Total..	247	31	278	100.0

authors kept a tally of the geese observed killed at several Alexander County shooting clubs and recorded whether they were shot as singles, from pairs, or out of flocks. The data gathered, table 18, show that geese shot as singles comprised 50 per cent of the total observed kill. Because single birds were outnumbered by individuals making up pairs and flocks, it is evident that they suffered a disproportionately large share of the kill.

In 1945, when examining bagged geese for sex and age, we asked each hunter whether the bird being checked was shot as a single, from a pair, or from a flock. Because of the two-bird limit, many hunters could easily remember the circumstances under which each of their birds was killed. In some instances we were able to examine geese that we had personally observed shot. The analysis of this portion of the total bag reveals that juvenile geese probably comprised 81 per cent of the number of geese shot as singles,

Table 19.—Age class of Canada geese and size of flocks from which they were shot. Data obtained from hunters at time of bag inspections in Alexander County, 1945.

NUMBER IN FLOCK	AGE CLASS OF GEES			TOTAL INDIVIDUALS
	Juvenile	Yearling	Adult	
One.....	78	6	12	96
Two.....	11	1	4	16
Three or more..	42	6	17	65
Total..	131	13	33	177

and that approximately 60 per cent of all juveniles bagged were flying alone when shot, table 19.

In most other years for which we have data, the juveniles contributed a disproportionately large share of the total kill, table 23. The extent to which juveniles were more vulnerable to shooting than older geese has been calculated from band-recovery ratios from these two age groups (see page 169). Sufficient data to indicate the approximate difference in vulnerabilities are available for only 1 year. In 1943, the vulnerability ratio in the Horseshoe Lake area was calculated to be 1.0 adult to 8.3 juveniles. Bag inspection data indicate that the ratio continued high in 1944 and 1945, table 23.

Further analysis of our band-recovery data reveals that young geese in their second spring of life, that is, on their return to the breeding grounds as yearlings, continued to be more vulnerable to hunters than the older birds, although the differential was not so great as at Horseshoe Lake. The vulnerability of yearlings compared with that of older geese is based on bandings and recoveries between 1941 and 1944.

The following formula was used to determine the relative vulnerability of yearlings and of older geese on the breeding grounds for the springs of 1942, 1943, and 1944.

$$\text{Vulnerability quotient } V = \frac{\begin{array}{l} \text{Number of recoveries of yearlings} \\ \text{from breeding grounds} \\ \text{Number of banded yearlings} \\ \text{(minus losses at Horseshoe Lake)} \\ \text{Number of recoveries of adults*} \\ \text{from breeding grounds} \\ \text{Number of banded adults* (minus} \\ \text{losses at Horseshoe Lake)} \end{array}}{\begin{array}{l} \\ \\ \\ \\ \end{array}}$$

By substituting in the formula the appropriate data from our banding files for the years 1942, 1943, and 1944, we have the following equation:

$$V = \frac{\begin{array}{r} 75 \\ 2415 \\ 20 \\ 1804 \end{array}}{\begin{array}{r} \\ \\ \\ \end{array}} = 2.8$$

* Older than yearlings.

Our calculations indicate that the average yearling was about 2.8 times as vulnerable to hunting by the Indians on the breeding grounds as was the average adult (older than 1 year) in the springs of 1942, 1943, and 1944.

Since the bulk of the Indian kill is made from April 15 to June 1, fig. 61, 5 months after the close of hunting in southern Illinois, it would seem that experience gained by the young geese in that interval does not greatly reduce their vulnerability on the breeding grounds. A crucial period that immediately follows their abandonment by the adults results in continued vulnerability of the yearlings to gun pressure.

There is ample evidence that this abandonment occurs just prior to nesting. Unless broken up by shooting, family groups at Horseshoe Lake are often maintained throughout the autumn and winter period. From observations made at his sanctuary, Jack Miner (1923) believed that goose families do not break up until they reach the breeding grounds. This belief is substantiated by the Indians, who have observed that the young of the previous year are separated from the adults shortly before the breeding season. The breeding adults in the captive goose flock at the Bright Land Farm near Barrington, Illinois, according to Charles Kossack of Barrington, are similarly known to drive off their yearling young at nesting time. "Cast off" young geese are on their own, without the guidance of adults, and probably are associated at first in small groups.

One of the reasons for the differential vulnerability of the yearlings on the breeding grounds was suggested in 1946 by John Gunnar and Gilbert Faries, lifelong residents in the James Bay area and experienced goose hunters. They stated that, when the first geese arrive in the spring, many of them are very tame and curious. Gunnar volunteered the opinion that the first arrivals are the nonbreeding geese (yearlings). He recalled that on one occasion, while he was in the Part-ridge Creek area, a flock of inquisitive Canada geese decoyed within 10 feet of his head, and he expressed the belief that the white garment he wore at the time was responsible for their curious behavior.

Similar lack of wariness in the other species of geese has been noted. Brandt (1943) says of the white-fronted goose at Hooper Bay, Alaska: "And immediately after the lifting of the ice embargo these groups disintegrated into mated pairs, excepting *small* bunches of bachelor males. These free-lance gallants, often in company with like possibly rejected suitors of other species of geese, spend their time moving abstractedly around in inquisitive flocks, and are *ludicrously easy to decoy*."*

Of the blue goose, Soper (1930) writes: "With the breeding birds resuming, or commencing nesting duties large numbers of nonbreeding geese were left to fly aimlessly about in carefree existence during the brief span of the arctic summer. These were the restless and irresponsible flocks and individuals which from now on were to be observed in the Camp Kungovik locality."

The higher mobility of yearling geese as compared with that of nesting pairs is a factor that may make the young birds readily available to Indians. Nesting adults are known to be extremely wary and secretive, and, unless they are especially sought after, their presence may be known only by chance. Lack of wariness on the part of yearling geese apparently lasts until they begin to band together. In the summer, large flocks, believed to be comprised mainly of yearlings, are extremely wary.

CRIPPLING LOSSES

As crippling losses are a component of hunting mortality, they should be considered a part of the total yearly allowable kill in any game species. Whether a goose ends up on the hunter's table or dies of wounds and furnishes a banquet for some scavenging predator, the net loss to the flock is the same. Reduction of the crippling loss must always be an objective if maximum utilization of a game species is to be achieved.

For many years, waterfowl shooting has been known to produce a considerable loss of unretrieved cripples—a loss that is high

* Italics by the authors of this paper. Boardman Conover, who was in the Hooper Bay area with Brandt, has informed the authors that many flocks exhibiting this kind of behavior were composed of nonbreeding yearlings.

in proportion to the number of birds bagged. In most cases the crippling loss reported for ducks amounts to at least 30 per cent of the number of birds bagged and in some situations one duck is lost for every one bagged (Errington & Bennett 1933, Hawkins & Bellrose 1939, Baumgartner 1942, Hochbaum 1944). In Michigan about 10 per cent of 105 ducks trapped and examined carried shot (Whitlock & Miller 1947), but what percentage of these ducks died later as a result of the prolonged effect of carrying shot is not known. Recent fluoroscopic studies made by the Illinois Natural History Survey of ducks trapped at Spring Lake on the Mississippi River and at Lake Chautauqua on the Illinois River revealed that approximately 25 per cent of the mallards migrating through these areas carry lead shot in their bodies as a result of shooting.

Goose shooting at Horseshoe Lake, 1940-1945, resulted in crippling losses similar to those reported to occur in duck hunting. To anyone who observed the shooting at clubs bordering the refuge at Horseshoe Lake in the years of this study, it was apparent that the height at which a goose flew over the hunters seldom determined whether it was shot at. The situation was aggravated by the heavy concentration of hunters; hunters in the first line of pits or blinds attempted to "reach" approaching geese before the birds flew over the next line of pits. Novice goose hunters usually underestimated distances, while expert shooters, disgusted with the ease with which geese leaving the refuge could be killed, sometimes found sport in attempting to "scratch down" the high birds.

High shooting, some observers believed, saved large numbers of geese by frightening them off before they could fly within killing range. This was undoubtedly true during the early part of a season when the geese were not working out of the refuge in great numbers, or in years when low kills were made, but late in a season when geese were so numerous in flight over club grounds that the majority of hunters, even those who indulged in high shooting, got their limits, or in a year of high kill rate when the season was limited by a predetermined kill, high or indiscriminate

shooting was a factor certain to cause needless crippling and increase the total loss.

In 1944, a questionnaire was circulated among goose hunters to obtain their own appraisal of their shooting. During the 21-day season, 103 hunters were asked questions about the following items: number of shells fired, estimate of geese lightly hit, number of geese severely crippled and not retrievable, and the number of geese bagged. An analysis of the accumulated data shows that the average bag per hunter-day was 1.69 geese. Since the average hunter success for all clubs in the vicinity for the entire season was 1.44 geese per hunter-day, it can be assumed that a fairly representative group of hunters was sampled.

The 103 hunters reporting estimated that with 1,374 shells they had bagged 286 geese and had severely crippled 51 geese; the number of geese crippled was equivalent to 18 per cent of the number bagged. This percentage probably represents the minimum crippling loss. The hunters reported that they had lightly hit an additional 176 birds, or a number equivalent to 61 per cent of the number bagged. Thus, according to their own estimates made the day of hunting or a day after, these hunters hit, with varying degrees of severity, and did not recover, a number of geese equaling 79 per cent of the number that they recovered. However, this figure is so high as to cast some doubt on its validity.

In 1945, Arthur S. Hawkins, then of the Illinois Natural History Survey, and the authors observed the shooting at several clubs and made on-the-spot tallies of the number of geese bagged and the number crippled but not recovered. The tally of crippled birds included only those that had been obviously and severely hit, but others may have suffered mortal body wounds without exhibiting a noticeable reaction to their wounds at the time of being shot. The hunters under observation bagged 253 geese but failed to recover an additional 62 badly crippled birds, most of them able to fly well enough to regain the lake within the refuge boundary, but so severely crippled as to be unable to survive the winter. Thus, in addition to each four geese bagged, ap-

proximately one additional goose died as a result of shooting—a minimum crippling loss of 25 per cent. At a few clubs the ratio of birds crippled to birds bagged frequently exceeded a ratio of one to one. Two instances of extreme crippling were observed: in one, four geese were crippled and none bagged, and, in the other, seven were crippled and six bagged.

From the various data presented above, we conclude that a conservative figure for the over-all loss owing to crippling at Horseshoe Lake is at least 30 per cent of the total bag. Crippling data are lacking from other areas in the flyway, but it is doubtful if the rate attained at Horseshoe Lake was exceeded. Where shooters are widely spaced and are not competing with each other to knock down the same high-flying birds, there is relatively less wild firing and hence less crippling.

Since crippling is more or less directly related to the number of shells fired, information was sought on the number of shells the average hunter expended to secure one goose. The hunters canvassed by questionnaire in 1944 reported that they fired an average of 4.8 shells per goose bagged.

In 1945, data of a similar nature were obtained by an examination of shooting pits at the end of the first day of hunting. Of the 42 pits examined at two club shooting grounds bordering on Horseshoe Lake, the average pit contained 37 recently fired shell casings. As each of the hunters at these clubs killed his limit of two geese, and as no more than two hunters were permitted in each pit, the average number of shells fired to kill one goose on opening day in 1945 was nine.

How does this score at Horseshoe Lake, where goose shooting was relatively easy, compare with goose-shooting scores elsewhere? On the basis of his goose-hunting experiences in the West, Major Askins (1945), a noted authority on arms, believes that one goose to three shells, when distances are less than 80 yards, is about the best score an average hunter can expect. Most of his shooting was of the pass variety, and he states that it is doubtful if his score was better than one bird in four shots.

Geese wounded near Horseshoe Lake generally attempted to regain the lake

either by flying or by eluding the hunter on the ground. Since hunters were not permitted to recover cripples that entered the refuge, club owners, at the opening of the 1943 season, were required to erect a 2-foot woven-wire fence between the pits and the lake to aid hunters in retrieving wounded geese that had been knocked down in the fields. Through this device, hunters secured a fair number of birds that would otherwise not have been recovered.

Crippled geese within the refuge were usually found apart from the flying birds, sometimes gathering in flocks of 10 or more. The strongest cripples swam about in the lake, where they sought shelter close to shore among the cypresses and snags, fig. 42, but the weaker ones rested on the lake shore. Few badly shot geese recovered from their wounds; many survived for a time, but in their weakened condition they became victims of predators. Raccoons consumed many dead geese (Yeager & Elder 1945). Although unable to catch healthy birds, these animals apparently sought out and killed many of the cripples, the remains of which were usually found along the shore line or on logs some distance from shore. A few carcasses were pulled under water and eaten by turtles. Skeletons of many geese have been observed on the lake bottom in years when cripple surveys have been made on ice. Undetermined numbers of geese sought shelter and died in parts of the lake that were inaccessible to man because of the large number of dead trees and fallen logs. Some cripples were caught by foxes and dragged into the woods on the refuge, where they were devoured; others died on hunting lands away from the lake. Consequently, a count of skeletons and carcasses around the shore line and on the island and club grounds represented only a portion of the total loss.

To determine at least the minimum number of unretrieved geese that died of wounds, counts were made of goose carcasses along both island and outer shore lines of the lake, as well as on the grounds of the principal goose clubs. The total counts of carcasses each winter, from 1940-41 through 1945-46, are given in table 20. Not all carcasses counted, of course, represented cripples that had died,

Table 20.—Number of carcasses of Canada geese counted on and near the Horseshoe Lake Game Refuge, 1940-41 through 1945-46.

SEASON	TOTAL CARCASSES COUNTED	GEESE FOUND DEAD PER 100 BAGGED AT LICENSED CLUBS AROUND REFUGE	INCLUSIVE DATES OF COUNTS
1940-41.....	466	3.61	January 19-20
1941-42.....	—	—	—
1942-43.....	421*	6.70	October 20- December 20
1943-44.....	1,048	9.39	December 17-28
1944-45.....	555	7.75	November 24- February 8
1945-46.....	648	14.58	December 6-31

* Estimated by W. H. Elder, then of the Illinois Natural History Survey, from counts on 10 sample quarter-mile strips of refuge shore line.

as some deaths were due to lead poisoning and disease. Data for the several years in table 20 are not directly comparable because the amount of outer shore line and the number of clubs surveyed for cripples varied annually. In general, coverage was increasingly extensive and thorough in successive years.

The legs and feet of the crippled geese, which seemed to be choice items of food to predatory animals, either were eaten where the birds were found or were carried off. A tally of 391 carcasses in 1945, a little over a month after the close of shooting, showed that only 21 per cent still retained both legs and that 5 per cent had but one leg. Many of these carcasses were fresh or only partially eaten when counted, and the number of legs eventually consumed by predators during the winter was estimated to be nearly 100 per cent. Because of the scarcity of legs, few carcasses yielded bands, a tally of which, when compared with the known kill and band recovery from hunters, would have permitted a fairly accurate appraisal of the crippling loss.

An analysis of our data on unretrieved cripples that later died indicates that adults succumb less quickly after being wounded than do juveniles. A week after the close of the 1944 season, during which 9.4 juveniles were bagged for every adult, the ratio of juveniles to adults found dead along the shore line of one club adjoining the refuge was 32:1. A month after the close of the season the ratio was down to 1.5:1.0. In a similar count a week after the close of the 1945 season, during

which 4.1 juveniles were bagged per adult, the ratio of juveniles found dead to adults found dead was approximately 3:1.

MISCELLANEOUS MORTALITY FACTORS

Although no attempt was made to investigate all causes of death in the Canada goose population of the Mississippi valley flyway, a few mortality factors, in addition to shooting, were studied.

Lead Poisoning

Lead poisoning in Canada geese has been recorded from widely separated parts of the country: near Galveston, Texas; Currituck Sound, North Carolina (Grinnell 1901); Barry County, Michigan (Pirnie 1935); St. Clair Flats, St. Clair County, Michigan (Howard 1934); and Columbia County, Wisconsin (Adler 1944).

Because Canada geese are chiefly grazers, they are less apt to ingest lead shot than are ducks, which secure much of their food off the lake bottoms by straining great quantities of mud through their bills to extract seeds. Among geese at Horseshoe Lake, deaths resulting from lead poisoning were most frequently observed in late winter and early spring during the period of study. Mainly responsible for this seasonal mortality from lead was, of course, the great abundance of lead shot available toward the close of the hunting season on the surface of cultivated fields over which shooting had been heavy. Diminishing food supplies as the season

advanced increased the likelihood that geese would pick up shot in fields planted to winter wheat, one of their principal foods in the Horseshoe Lake area. In areas where the ground held much moisture and the wheat plant was devoured down to the roots, some soil and probably any shot that happened to be present were ingested. Geese at the refuge were observed to devour considerable quantities of soil at times, particularly in winter. In certain farmed feeding areas, holes as much as 6 or more inches deep and several times as wide were created by the geese in their ostensible search for food. This type of feeding increased the likelihood of the birds occasionally swallowing lead shot.

"Tip-up" feeding by Canada geese in the water of the Horseshoe Lake area was observed in late winter. This habit may have been a response to a reduced food supply on land. In 1942, a slough on the west side of the lake was a favored "tip-up" ground. Dr. William H. Elder, while with the Illinois Natural History Survey, when surveying this area for cripples, found 13 dead or dying geese on the ice or close to the shore line. Of 23 geese autopsied by Dr. Elder in late winter, 20 were found to have died of lead poisoning, 18 of these containing shot in their gizzards.

Paul S. Smith of the United States Fish and Wildlife Service, who conducted a series of tests on one of the most heavily shot club grounds, found about one lead shot per square foot of top soil, 1 inch in depth. Only the fact that the grounds of hunting clubs were cultivated each year prevented losses due to lead poisoning from assuming greater proportions. The potential danger from lead shot increased each year of the study, and the proximity of heavily shot fields to such an important concentration area as the Horseshoe Lake Game Refuge constituted a significant hazard to the geese wintering there.

Starvation

A Canadian Indian whose hunting grounds lie in the Lawapiskau River* country related that during late springs, when snow remained on the ground for some time after the arrival of Canada

geese, he found dead birds that were in a very emaciated state, a condition that he attributed to a lack of available food. Because it is likely that, as a result of disease, lead poisoning, or crippling, a few geese succumb soon after their arrival on the breeding grounds, it is impossible to assess from this single report the importance of starvation as a cause of death in Canada geese. Nevertheless, there is some evidence that a food shortage in late spring may result in death of the weakest birds. In the second week of May, 1947, when the rivers and creeks were frozen and the country was still under several feet of snow, geese shot by Indians at the south end of James Bay were reported as having only willow catkins in their gizzards.

Bound Crop

Occasionally Canada geese were found in the vicinity of Horseshoe Lake in a thin, weakened state and with greatly



Fig. 65.—Esophagus, proventriculus, and gizzard of a Canada goose found dead on the Bright Land Farm near Barrington, Illinois. Death in this case was due to lead poisoning from 38 shot found in gizzard. Food impaction is the result of lead poisoning, which often causes paralysis of the digestive tract in Canada geese and other waterfowl. (Photograph by Charles W. Kossack.)

distended crops. Examination of these individuals revealed that an impacted crop was often the primary cause of their condition, and, though operative measures were tried, few of these geese had sufficient stamina left to survive. Their crop contents usually consisted of a tightly packed mixture of wheat browse, corn,

* This river flows into James Bay 20 miles south of the Albany River.

and cowpeas, or soybeans, and frequently leaves and portions of the stems of the two legumes. In some of these, bound crop may not have been the direct cause of loss of weight and strength; instead it may have been the result of partial paralysis and weakness resulting from lead poisoning, fig. 65.

C. E. Laughery, formerly refuge manager at the Horseshoe Lake Game Refuge, informed us that geese with bound crops were most frequently found in years when

several weeks after most of the local corn crop had been utilized or removed from the fields, fig. 66. While consumption by geese of shattered and otherwise wasted soybeans may seem desirable, these beans may sometimes have contributed to a number of deaths resulting from bound crop.

In the winter of 1943-44 in particular, Paul S. Smith, when surveying the vicinity of the refuge, found a number of dead geese, their crops tightly packed with soybeans. These birds were said to differ



Fig. 66.—Canada geese in a harvested soybean field near Horseshoe Lake, autumn 1946.

a considerable acreage on the refuge was planted to cowpeas. Cowpea fields attract large numbers of geese long after the bulk of the crop has been consumed. A few geese, while searching for peas, evidently consume fibrous and relatively indigestible portions of the plant. The presence of such material in the crops of geese may be responsible for impactions.

In recent years, soybeans were planted extensively in southern Illinois, and the geese tended to utilize this crop to a greater extent each year. There was frequently much wastage in harvesting these beans; many fields in the vicinity of Horseshoe Lake were not combined until an appreciable portion of the crop had been lost through shattering. As a result, beans in abundance were available to geese for

from the crop-bound birds described above in that they were particularly heavy and fat. Probably in the winter certain geese fed more extensively on soybeans than on other foods and, as soybeans have a high protein and fat content, these individuals became heavier than the average goose of the area. Apparently these geese died after drinking water when their crops were crammed with beans. The pressure resulting when the beans imbibed water and swelled may have been the direct cause of death in such cases; the mechanism of the lethal effect is not known to us.

Geese frequently stuff their crops tight with corn, but in only one instance was corn suspected of being an indirect cause of death. This individual with an overloaded crop, fig. 67, became agitated in

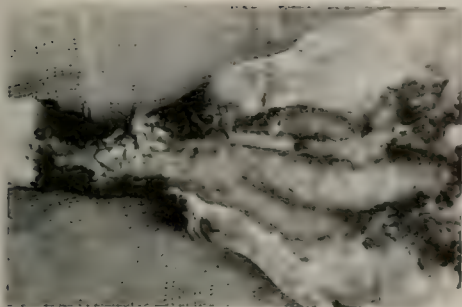


Fig. 67.—The Canada goose is a voracious eater. This individual with an overloaded crop became frightened when a game technician entered the trap in which it had been caught. It had extreme difficulty in breathing and died a few minutes later.

the trap and died shortly thereafter, exhibiting the syndrome typical of anoxia.

Rough tests of the swelling properties of dry soybeans and corn revealed that the beans present a much greater hazard as food for geese than does the corn. Soybeans and corn were soaked in water for intervals varying from 30 minutes to 6 hours. Water displacement measurements showed that the soybeans increased their bulk at a rate approximately three times the rate corn increased its bulk. At the end of 3 hours, soybeans had increased their bulk by 85 per cent and corn by 30 per cent. These data and field observations suggest that soybeans and cowpeas may not be ideal crops to plant for the express purpose of providing food for wintering concentrations of Canada geese.

Predators

The red fox is probably the only predator at Horseshoe Lake that is capable of catching sound, healthy geese. Remains of geese found in cornfields late in the autumn point to predation by foxes, but probably most carcasses represented secondary predation involving birds crippled during the hunting season.

In each year covered by this study, a pair of bald eagles nested on the island in Horseshoe Lake, and both adults and juveniles were observed regularly throughout the autumn and winter periods. In the autumn of 1945, the eagle population on the refuge numbered at least five. Eagles were frequently seen feeding on

crippled geese that had died, and in December, 1945, several eagles were observed by Paul S. Smith to attack a live goose (probably a weak cripple) that was frozen to the ice by its feet and breast feathers. Eagles were never seen to attack a sound, healthy goose.

Bald eagles are reported to feed on wounded geese in the Port Joli area of Nova Scotia, and never to be absent from the area as long as the geese remain (Tufts 1932). A discussion of predators on the breeding grounds will be found in the section on "Productivity."

Diseases

Only two diseases were investigated at Horseshoe Lake: tracheitis and aspergillosis.

Tracheitis.—In January, 1945, a number of geese trapped were found to have wheezy voices, indicative of a congested tracheal condition. Two of these birds eventually died, and the lungs and trachea of one were sent to the Department of Animal Pathology and Hygiene, University of Illinois, for examination. The cause of death was diagnosed as tracheitis, pulmonary congestion, and edema.

The symptoms of the disease as observed at Horseshoe Lake were a voice pitched higher than normal, a distinct "wheeze," and heavy, spasmodic breathing, accompanied by a forward throw of the head and open mandibles as the bird gasped for air, fig. 68. As the disease progressed, the effort attendant upon the intake of



Fig. 68.—Canada goose near death from tracheitis. Symptoms of this disease are a forward throw of the head and neck and gaping as the bird gasps for air.

air became increasingly spasmodic and violent because of the whitish exudate that accumulated in the trachea at the junction of the bronchi.

Both field experience and laboratory findings indicate that tracheitis is infectious, but the nature of the infectious agent is uncertain. Graham & Thorp (1931) have reported that a Canada

the typical nodules associated with *Aspergillus* infections were present throughout the body cavity, fig. 69, left. In December 1946, a second juvenile goose was found dead from an *Aspergillus* infection. Post-mortem examination of this specimen by the Department of Animal Pathology and Hygiene revealed that the air sacs were partly, or in some cases completely, filled

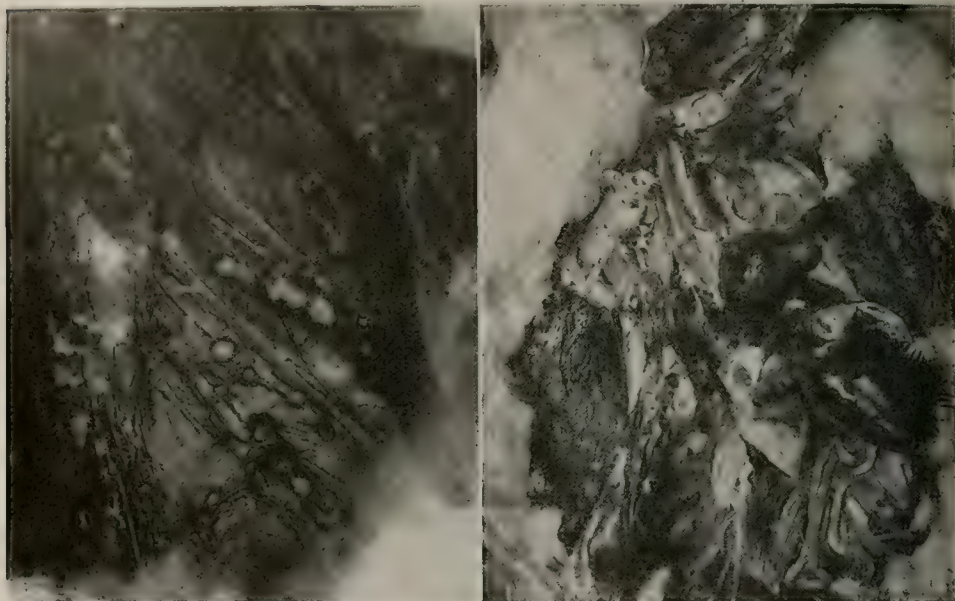


Fig. 69.—Aspergillosis in Canada geese. The nodules of *Aspergillus* infection shown in the illustration at left are on the lateral wall of the body cavity. In the goose shown in the illustration at right, the air sacs are the principal foci of infection. Both specimens were juveniles.

goose from a farm flock had clinical symptoms analogous to acute laryngotracheitis in domestic fowl. However, autopsy of the goose revealed that the lung contained foci of mycotic pneumonia.

Aspergillosis.—The manifestations of aspergillosis in waterfowl have been adequately described by Phillips & Lincoln (1930). While outbreaks are known to occur occasionally in duck populations (Phillips & Lincoln 1930; Pirnie 1935; Bellrose, Hanson, & Beamer 1945), only one instance of its occurrence in Canada geese in the wild has been recorded previously (Dow 1943).

At Horseshoe Lake on November 7, 1946, a juvenile Canada goose was found in a much weakened condition. Within a day it was dead, and autopsy revealed that

with a fungus growth, fig. 69, right, that upon cultural examination presented the characteristics of *Aspergillus fumigatus*.

Parasites

Both internal and external parasites were taken from Canada geese wintering at Horseshoe Lake.

External Parasites.—Four species belonging to four different genera of chewing lice or Mallophaga were taken from Canada geese at Horseshoe Lake. Specimens of *Trinoton querquedulae* Linnaeus collected in the winter of 1945–46 were identified by Dr. Carl O. Mohr, then of the Illinois Natural History Survey staff. The following species, collected from a dead goose in 1934, were identified by R. O. N. Malcomson: *Anatoecus*

ferrugineus Giebel, *Esthiopeterum crassicornae* (Scopoli), and *Ornithobius goniopleurus* Denny.

Internal Parasites.—Flukes were frequently encountered in the cloacae of Canada geese at Horseshoe Lake when examinations were made for sex and age. A number collected in the winter of 1945-46 were referred to Dr. L. J. Thomas of the Department of Zoology, University of Illinois, for identification. In his report he identified these specimens as *Echinostoma revolutum* and *Prosthogonimus* sp.; specific identification in the latter genus was impossible because of the poor condition of the specimen.

PRODUCTIVITY

It is important to know several months in advance the probable population of any game species at the start of a hunting season in order to determine what hunting restrictions will be necessary in that season. Populations of nonmigratory game can be estimated or inventoried before the hunting season more easily than can those of such migratory species as the Canada goose, which nests in comparatively inaccessible regions. Because of the length of time generally required before they can be officially approved, hunting regulations for migratory waterfowl must be decided upon while the actual size of the fall population is still an unknown. Thus, it is desirable to be able to forecast the population accurately from data obtained during the previous season. Forecasts can be made more easily for a population of limited size and distribution, such as the Horseshoe Lake goose flock, than for immense, continent-wide populations.

To interpret and predict population trends from flocks on their wintering areas, such questions as these must be answered: What is the age ratio, within the flock, of juveniles to adults? What are the survival rates of various age and sex groups? How long do geese live? How many or what percentage of a population attain breeding age? What is the ratio of males to females? Does a disproportionate kill occur in the various sex and age groups? Answers to these questions have been sought in studies of the

Canada goose at Horseshoe Lake and on the breeding grounds, and in records of geese banded at the Miner Sanctuary.

Breeding Potential

The theoretical capacity of a species to produce young is determined by mating habits, age at reproductive maturity, ratio of males to females, and number of young produced per season. Information in the literature on these subjects is briefly summarized to aid in interpreting the significance of related data from the Mississippi flyway.

Mating Habits.—The Canada goose is monogamous and, judged from the habits of captives, fig. 70, remains paired to the same mate as long as both are alive. In captivity, individuals have been known to re-pair after the death of a mate (Montgomery 1938), although in some cases several years may elapse before remating takes place (Miner 1923). Remating experiments with Canada geese by Charles Kossack and Carleton Beckhart at the Bright Land Farm near Barrington, Illinois, have shown that a very high percentage of captives will remate the first spring following separation from their mates.

Reproductive Maturity.—At least 2 years are required for the Canada goose to reach sexual maturity in the wild, and in captivity the age of maturity is often 3 years and sometimes 4 (Dutcher 1885, Bailey 1913, Taverner 1922, Wilfrid 1924, and Forbush 1925). Studies made by the Illinois Natural History Survey of the semicaptive flock at the Bright Land Farm revealed that 25 per cent of the geese bred during their third year (Elder 1946).

Definite information on Canada geese breeding in the wild at 2 years of age is lacking. If the presence of an open oviduct is a sign of sexual maturity or an indication that eggs have been produced, data from Horseshoe Lake indicate that in the wild practically all females are productive at 2 years of age. However, until further information is available, inclusion of all wild geese in their third year of life in the breeding component of the population must be considered tentative. Of 54 females banded as juveniles and retrapped and examined at Horseshoe Lake in their



Fig. 70.—Female Canada goose and newly hatched young on the Bright Land Farm near Barrington, Illinois. (Photograph by Charles W. Kossack.)

second winter, all possessed closed oviducts (at about $1\frac{1}{2}$ years of age); but of 18 females retrapped and examined in their third winter (at about $2\frac{1}{2}$ years old), all but one possessed open oviducts (Hanson 1949a).

The duration of fertility is probably not a factor limiting the productivity of Canada goose populations, as captives have been known to raise young at ages that far exceed the length of life of most

individuals in the wild, few of which live longer than about 5 years (see section on "Population Survival").

Sex Ratios.—Sex ratios of Canada geese as they were obtained from trapping and from bag inspection in the vicinity of Horseshoe Lake are given in tables 21 and 22. In the juvenile age class, trap data for the period of study indicate a slight but statistically significant excess of males; bag data, on the other hand, indicate no

Table 21.—Number of male and female juvenile Canada geese newly trapped and banded and number examined in bag at or near Horseshoe Lake, 1940-41 through 1946-47.

SEASON	GEESSE Banded			GEESSE INSPECTED IN BAG		
	Total Number Banded and Sexed	Number Females	Per Cent Females	Total Number Inspected	Number Females	Per Cent Females
1940-41.....	143	68	47.6	213	110	51.6
1941-42.....	272	128	47.1	50	37	74.0
1942-43.....	619	284	45.9	549	254	46.3
1943-44.....	1,379	634	46.0	354	140	39.5
1944-45.....	607	272	44.8	379	184	48.5
1945-46.....	196	106	54.1	689	341	49.5
1946-47.....	296	102	34.5	—	—	—
Total.....	3,512	1,594	—	2,234	1,066	—
Average.....			45.4			47.7

significant variation from a 1:1 ratio. In the adult age class, according to trap data, there is a significant preponderance of males, but bag data fail to show a significant deviation from a balanced sex ratio.

Which of the ratios for the adults in table 22 more nearly represents the actual sex ratio for that age class in the population? Trap ratios might be more nearly correct because observations of banded birds (banded on left or right foot according to sex) feeding around the traps have revealed no greater wariness on the part of either sex. On the other hand, a preponderance of males would not be surprising, as a disproportionate loss of females could be expected to occur during the breeding cycle. The validity of the adult bag ratio as a representation of the actual sex ratio in the adult group is

questionable because it indicates that the ratio of the sexes in this older age group is more evenly balanced than the ratios for the juveniles found from either trapping or bag inspection. The actual sex ratio in the adult population may lie somewhere between the two figures given in table 22.

Number of Young.—Five eggs represent about the average clutch size of the Canada goose in the wild, according to other observers. At Honey Lake, California (Dow 1943), 169 nests examined in 1939 contained an average of 5.09 eggs per nest, and 249 nests examined in 1940 contained an average of 5.10 eggs. A study of goose nesting at the Bear River marshes of Utah revealed an average of 4.88 eggs per clutch for 84 nests (Williams & Nelson 1943).

Table 22.—Number of male and female adult Canada geese newly trapped and banded and number examined in bag at or near Horseshoe Lake, 1940-41 through 1946-47.

SEASON	GEESSE Banded			GEESSE INSPECTED IN BAG		
	Total Number Banded	Number Females	Per Cent Females	Total Number Inspected	Number Females	Per Cent Females
1940-41.....	170	81	47.6	55	22	40.0
1941-42.....	124	47	37.9	29	11	37.9
1942-43.....	404	187	46.3	212	104	49.1
1943-44.....	950	416	43.8	90	50	55.6
1944-45.....	246	82	33.3	40	20	50.0
1945-46.....	114	49	43.0	168	84	50.0
1946-47.....	205	67	32.7	—	—	—
Total.....	2,213	929	—	594	291	—
Average.....			41.9			48.9

The number of eggs produced by captives is surprisingly close to the production attained by wild birds. In 1942, 54 pairs of Canada geese on the Bright Land Farm produced 260 eggs, or an average of 4.81 eggs per pair. Several people experienced in raising Canada geese have stated that the number of eggs laid may vary with the age of the birds. Dutcher (1885) cites a game breeder on Long Island who claimed that 4 eggs are laid the first year of breeding, 5 the second, and 6 or 7 thereafter. Miner (1923) also states that "a young goose will lay four eggs the first year [of laying] and usually five the second."

Actual Productivity

The number of young birds brought to the flying stage is always somewhat less than the theoretical maximum. Fertility of Canada goose eggs is evidently high. In California and Utah, an egg fertility of 93 and 94 per cent, respectively, was found. However, flooding, predators, and other agents may destroy as high as 40 to 48 per cent of the nests in California (Dow 1943) and thus reduce production of young. Consequently, the annual production for all pairs that nest may average only 2.48 to 2.84 goslings per pair, or about 50 per cent of the number of eggs produced. In Utah, 84 nests studied yielded an average of 3.9 goslings per nest (Williams & Marshall 1938). Second nestings are sometimes attempted, a factor that would somewhat increase the average annual productivity per pair.

Information volunteered by the Indians at Moose Factory, Fort Albany, and Attawapiskat suggests that the red fox is the predator most destructive to Canada goose nests in the James Bay area. The extent to which foxes are harmful to goose nests is probably inversely related to the population levels of other prey species. In 1946, a year during which foxes were abundant, but snowshoe hares, muskrats, grouse, and ptarmigan were low in numbers, Indians reported finding many Canada goose nests destroyed by foxes. When interviewed in the summer of 1947, one Indian said, "The foxes are now low in numbers. Let's wait and see what kind of luck the geese have in raising young this year."

These attitudes by a native people, who are the keenest of observers, should be given careful consideration. Recent studies have generally confirmed the belief that predators have little effect in controlling the numbers of cyclic prey species, but in the case of Canada geese we are dealing with a bird that is normally of secondary importance as a prey species and that at present is not known to be cyclic. If geese and other waterfowl are subject to increased predation by foxes when these animals are at the peak of their cycle, it is conceivable that the numbers of waterfowl could be measurably affected by fox predation.

A few Indians that remain in the interior occasionally take goose eggs, but as the greater number of the Indians are at the coastal posts, fig. 55, during the nesting season, the importance of Indian predation is negligible.

Juvenile mortality in Canada geese appears to be small. In Utah a 3 per cent decrease in average brood size occurs over a period of a month (Williams & Marshall 1938). Little is known concerning predation on broods, but in one recorded instance in British Columbia ring-billed gulls devoured a brood of newly hatched goslings (Munro 1936).

The scarcity of natural enemies in the James Bay muskeg area normally insures small losses of goslings to predators; coyotes are absent, wolves almost nonexistent; lynxes, minks, martens, fishers, and otters are generally scarce, and wolverines are extremely rare. Probably foxes, abundant at the peak of their cycles, are predators of consequence only in years in which populations of snowshoe hares and other prey species are low. Great horned owls are fairly common and may account for the loss of a few young geese.

Data From Horseshoe Lake

The degree to which goose productivity measurements at Horseshoe Lake are a valid measure of the actual productivity of the Horseshoe Lake flock on the breeding grounds is dependent upon the magnitude of the losses between the James Bay area and Horseshoe Lake (see section on "Annual Bag").

The autumn kill by the Canadian Indians is small, fig. 61, so that, even if more



Fig. 71.—Type of trap used to catch Canada geese at Horseshoe Lake. Trap consists of eight wood and wire frames roofed over with twine netting and supported with guy wires. Open ends are closed off by tripping a pipe-weighted, twine curtain from a blind.

young than adults are killed in proportion to their numbers, the ratio of juveniles to adults in the flocks is not changed appreciably by the time the geese migrate southward. The scarcity of band recoveries between James Bay and southern Canada further indicates that the flocks are still largely intact when they reach the northern border of the United States. From fig. 38 it is evident that the majority of the geese have arrived at the Horse-

shoe Lake Refuge by November 1. As the bulk of the kills north of the refuge are made after this date, fig. 62, most of the flocks that arrive at the refuge have been only moderately depleted by shooting; band recoveries indicate that total hunting losses between the Canadian border and Horseshoe Lake are usually 5 to 6 per cent of the southward bound population. Because of the small migration losses in the population, the over-all ratio of young



Fig. 72.—Canada geese feeding into drop curtain trap at Horseshoe Lake.

to old in the flocks as they arrive in southern Illinois probably does not differ greatly from ratios existing at the time the family groups start their southward migrations; therefore, we believe that age and sex ratios at Horseshoe Lake furnish reasonably accurate measures of actual productivity ratios in most years.

Trapping data and data from bag inspection and band recoveries combined have been used in measuring production of the Canada geese wintering at Horseshoe Lake.

The age ratios of the geese caught in traps are believed to be fairly representative of the untrapped population for the following reason: No significant difference was observed in the wariness of geese of the various age classes as the birds entered the traps (many geese were color-banded to indicate age classes). Many catches consisted of individuals that had entered the traps, fig. 71, as parts of a busily feeding wedge; such catches would not represent selective trapping, fig. 72.

The ratio of juveniles to adults during the early part of the autumn no doubt differs to some extent from the ratio after the hunting season because of the proportionately greater kill of juveniles, table 23, but we are not able to demonstrate the extent of this difference from the data at hand.

The total annual catch since the winter of 1943-44, excluding repeats, includes a large percentage (5.4, 22.5, 42.7, and 30.0 per cent, table 1) of geese trapped and banded in previous years (trap re-

turns), many of which are accompanied by their unbanded young. Therefore, the ratio of juveniles to adults among the newly banded birds, table 23, is not indicative of the age ratios in the flock as a whole, as it necessarily excludes the many banded adults that returned to the traps.

The ratio of juveniles to adults for entire-season catches is given in table 24. The figures for the season catches in this instance include the geese trapped in a specified season but banded in a previous season (trap returns) as well as the newly banded birds, but they exclude birds banded and re-trapped in the same season (repeats). These data more nearly represent the actual juvenile-adult ratio in the flock than do the data on newly banded geese given in table 23.

Data from bag inspection are indicative of true flock ratios only when they are corrected for differential hunting vulnerability of the juveniles by means of trap and band-recovery data. Age ratios derived directly from band-recovery data do not accurately reflect the age ratios in the total population for the same reason that the age ratios of unbanded geese in the hunters' bag do not, namely, that the banded juveniles are shot more heavily in proportion to their actual numbers than are the banded adults. However, age ratios derived from band recoveries can be used to correct bag ratios for the disproportionate kill of juveniles as follows: (1) Determine the relative vulnerability to shooting of the juveniles and the adults. (2) Use the vulnerability quotient of the

Table 23.—Number of juvenile and adult Canada geese newly trapped and banded and number examined in bag at or near Horseshoe Lake, 1940-41 through 1946-47.

SEASON	GEESE Banded			GEESE INSPECTED IN BAG		
	Total Number Aged	Number Juveniles	Per Cent Juveniles	Total Number	Number Juveniles	Per Cent Juveniles
1940-41.....	313	143	45.7	284	226	79.6
1941-42.....	398	274	68.8	79	50	63.3
1942-43.....	1,023	619	60.5	761	549	72.1
1943-44.....	2,329	1,379	59.2	173	158	91.3
1944-45.....	853	607	71.1	500	452	90.4
1945-46.....	310	196	63.2	857	689	80.4
1946-47.....	502	296	59.0	—	—	—
Total.....	5,728	3,514	—	2,654	2,124	—
Average.....			61.3			80.0

Table 24.—Productivity of the Horseshoe Lake flock as shown by trapping and bag-inspection ratios.¹

SEASON	FROM TRAPPING					FROM BAG INSPECTION
	Total Number of Individuals Trapped of Known Age-Class and Sex ²	Number of Breeding Adult Females Trapped ³	Number of Juveniles Trapped	Juveniles per 100 Adult Females	Juveniles per 100 Yearlings and Adults	Juveniles per 100 Yearlings and Adults
1940-41.....	313	—	143	—	84	—
1941-42.....	408	—	274	—	204	—
1942-43.....	1,054	—	619	—	142	—
1943-44.....	2,462	—	1,379	—	127	126
1944-45.....	1,101	136	607	446	123	—
1945-46.....	541	88	196	223	57	—
1946-47.....	717	114	296	260	70	—
Total.....	6,596	338	3,514	929	807	
Average.....				325	114	

¹ See page 168 for explanation of reasons figures in this table differ from those in table 23.
² Numbers in this column include returns (geese banded in previous years).
³ About 2¼ or more years old at time of trapping.

juveniles to correct bag ratios for the disproportionate numbers of juveniles lost through shooting.
The vulnerability quotient of the juveniles is obtained by the following formula, suggested by Frank C. Bellrose:

Number of band recoveries from juveniles

Number of juveniles banded before end of hunting season

Vulnerability quotient V =

Number of band recoveries from adults

Number of adults banded before end of hunting season

Data that are perhaps numerous enough to use in determining the vulnerability of the juveniles as compared with the vulnerability of the adults are available only for the 1943 hunting season.
In 1943:

81

Juvenile

Adult

754

6

466

= 8.34

According to these calculations, at Horseshoe Lake in 1943, the juveniles were 8.34 times as vulnerable to shooting as were the adults. With this figure available, it is possible, assuming the vulnerability quotient to be a true measure of vulnerability of the juveniles, to correct the age ratios obtained from bag inspection, which, by virtue of the higher vulnerability of the juveniles, is weighted in favor of this group as compared with the adult group in the total surviving population.
To correct age-ratio data obtained from bag inspection, it is assumed that the following formula is true, in which V is the vulnerability quotient calculated above from the trap and band-recovery data.

Ratio

Juveniles in population

Adults in population

=

Number of juveniles in bag

Number of adults in bag

V

To solve for the juvenile-adult age ratio in the surviving population in 1943, the proper values from table 23 and the calculated V above are substituted in the formula.

$$\text{Ratio (1943)} \frac{\text{Juveniles}}{\text{Adults}} = \frac{15}{8.34}$$

$$\text{Ratio (1943)} \frac{\text{Juveniles}}{\text{Adults}} = \frac{10.53}{8.34} = 1.26$$

Then the corrected age ratio is 1.26 juveniles to 1.0 adult.

The ratio of juveniles to adults found above from corrected bag ratios for 1943 is close to the age ratio found from trapping for 1943 (127 juveniles to 100 adults, table 24). Over a 7-year period the juvenile age class comprised about 53 per cent of the birds in the Horseshoe Lake flock, table 24.

Not only is it important to know what percentage of the flock is composed of juveniles each year for a significant analysis of productivity; it is important to know also the production of young in relation to the number of mature females—birds that are $2\frac{1}{2}$ or more years old when wintering at Horseshoe Lake. By relating productivity to only the sexually

mature females, compensation can be made in statistical analyses of the flock for annual changes in the percentage of non-breeding yearlings as well as for changes in ratio of adult males to adult females.

These productivity figures will be at variance with the impression that the average hunter gets from the flock at Horseshoe Lake. This hunter, on viewing the impressive concentration of geese at Horseshoe Lake, thinks that the total number of mated pairs in the flock in the following spring will equal the total population divided by two. Since he has heard that geese annually lay 5 or 6 eggs, he assumes that there will be an impressive increase for the next hunting season, and, thinking in terms of himself, anticipates more shooting. When informed that the flock may be even smaller in numbers at its peak in the autumn than it was at the close of shooting the previous year (as actually happened in the autumns of 1944 and 1945), in spite of the young added to the flock as a result of the breeding season, he may be dubious as to the competence of his informer.

The layman often fails to take into account the fact that Canada geese do not

Table 25.—Age and sex composition of the Horseshoe Lake flock, 1944–45 through 1946–47, as shown by trap catches of unbanded and previously banded geese.

AGE AND SEX CLASSIFICATION	SEASON						ALL SEASONS	
	1944–45		1945–46		1946–47		Total Number Trapped	Per Cent
	Number Trapped	Per Cent	Number Trapped	Per Cent	Number Trapped	Per Cent		
Adult males ¹								
$2\frac{1}{2}$ years or more.....	212	19.3	118	21.8	221	30.8	551	23.4
$1\frac{1}{2}$ years (yearlings).....	96	8.7	75	13.9	44	6.1	215	9.1
Total.....	308	28.0	193	35.7	265	35.9	766	32.5
Adult females ²								
$2\frac{1}{2}$ years or more.....	136	12.4	88	16.3	114	15.9	338	14.3
$1\frac{1}{2}$ years (yearlings).....	50	4.5	64	11.8	42	5.9	156	6.6
Total.....	186	16.9	152	28.1	156	21.8	494	20.9
Juveniles								
Males.....	335	30.4	90	16.6	194	27.1	619	26.3
Females.....	272	24.7	106	19.6	102	14.2	480	20.3
Total.....	607	55.1	196	36.2	296	41.3	1,099	46.6
Grand total.....	1,101	100.0	541	100.0	717	100.0	2,359	100.0

¹ Aging techniques separating yearling males from males $2\frac{1}{2}$ years old or older in fall and winter, about 85 per cent accurate.

² Aging techniques separating yearling females from females $2\frac{1}{2}$ years old or older in fall and winter, about 99 per cent accurate.

breed until they are at least 2 or 3 years old, and that at least one-half of the birds he sees will still be sexually immature in the spring; that an excess of males exists in the birds of breeding age, table 25; that members of broken pairs may be slow to mate; that some pairs each year are not successful in rearing a family; and that natural losses as well as the Indian kill are taking place in the intervening months. The actual number of sexually mature females upon which production in the coming spring is dependent may comprise only a small segment of the winter flock, in some years as low as 12 to 17 per cent, table 25.

A rapid method of distinguishing yearlings from older geese, for use on live birds in the field, was not developed until the fall of 1944 (Hanson 1949a). Since the more nearly complete data from 1944-45 through 1945-46 were collected during and after hunting seasons in which higher rates of loss occurred among juveniles than among adults, the actual ratios of juveniles to breeding females existing *before* the shooting began would be somewhat higher than those indicated in table 24; the trap ratios in table 24 differ from the indicated ratios or percent-

ages in table 23 only in the respect that the ratios in table 24 are based on the entire catch (exclusive of repeats) rather than on newly banded birds alone.

Theoretical vs. Actual Productivity

Data in the literature and from the captive flock at Bright Land Farm indicate that each pair of Canada geese would produce about 5 juveniles annually if all eggs laid were fertile, if all hatched, and if the young were raised to maturity without loss. Actual annual productivity, however, as indicated by the average brood sizes found in Utah and California, appears to be in the neighborhood of 3 to 4 young per nesting female or per pair. We have computed the ratio of juveniles to breeding females in the Horseshoe Lake flock as found from trapping. It was assumed that all females are sexually mature at about 2 years of age. The productivity of these females was computed from figures in table 24 to be, in 1944-45, 4.46, in 1945-46, 2.23, and, in 1946-47, 2.60 young per adult female.

Flock Sizes

Several decades ago, Phillips (1916) recorded his observations on the sizes of goose flocks in Massachusetts and presented evidence to show that in most instances these flocks were single families or groups of families. For flocks of less than 10 individuals, groups of six and seven individuals were most numerous; for flocks numbering between 10 and 30, groups that were multiples of five were most frequent. Unbroken families as large as 10, two adults and eight young, have been observed by the Miners at their refuge.

Flock counts have been made at Horseshoe Lake since 1941. Our analysis of these counts is limited to flocks of nine or less in number, because in this area a group of nine birds is the largest that we have observed to behave as a family unit. All individuals in this family, which were color-banded and of known age and sex, were repeatedly observed or trapped together.

Family-flock sizes at Horseshoe Lake and other areas for which we have data are shown in fig. 64. The frequency with which each family-flock size occurs is ex-

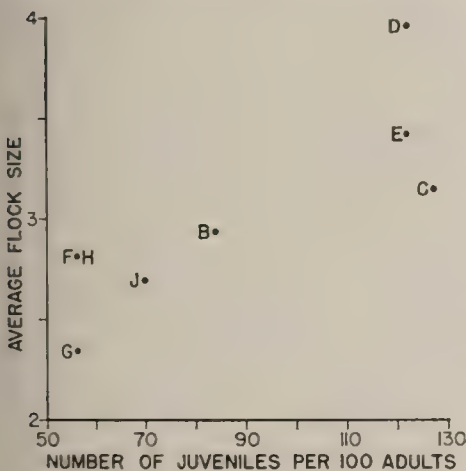


Fig. 73.—Relation of average flock size to productivity. Note that the average size of flocks in southern Wisconsin after light hunting losses was identical with the size of average flocks at Horseshoe Lake prior to hunting. *B-H* were derived mainly from data in fig. 64 and table 24. *J* represents data for 1946-47, shown in table 24 but not in fig. 64.

pressed as a percentage of the total observations.

From these data we suggest:

1. That the average family-flock size in late summer or early autumn may furnish a rough index of the age ratio within a large population, fig. 73; from this ratio the success of nesting the previous spring may be inferred, *A* and *D* in fig. 64.

2. That the average family-flock size in middle or late autumn, when compared with similar data gathered the same year before the opening of the hunting season, is indicative of the degree to which family groups have been broken through shooting. (Compare *F* and *G* in fig. 64.)

POPULATION SURVIVAL*

One of the objectives of the Canada goose research program reported in this paper was to determine through trapping and banding the annual mortality rate and the average longevity of Canada geese in the Horseshoe Lake flock in the period 1941-1946 and to compare the annual mortality data derived from the banding at Horseshoe Lake with similar data derived from the banding of Mississippi flyway geese at the Jack Miner Sanctuary in the period 1925-1944.

Definition of Terms

In the following discussion, *age class* refers to a group of geese, all of them hatched in a given year. A *banding class* includes all geese banded in a given season regardless of age at time of banding. The computed percentage of geese of a banding class alive each year in a series of successive years following banding comprises a *survival series*. This series may be computed from data in a *band-recovery series* (recoveries of bands from birds reported dead in any of several successive years after banding) or from data in a *trap series* (returns of banded birds to the traps in any of several successive years).

* The senior author is responsible for this section. As he carried out the trapping program at Horseshoe Lake and the compilation of the Miner recovery data in Ottawa, Canada, he is fully conscious of the inadequacies and bias in the data on which the following discussion is based. These inadequacies and bias do not permit the data to be treated by the customary methods. The methods used by-pass some of the shortcomings of the data, but, in the final analysis, the results presented only produce an approximation of the true picture. The reader should bear this point in mind in evaluating the results presented. It was deemed advisable to exploit the data as far as possible rather than disregard them altogether because of an acute awareness of their vagaries.

Table 26.—Hypothetical catches of Canada geese to illustrate difference between a trap series and a return series.

SEASON	NUMBER OF GEESE Banded	NUMBER OF Banded GEESE RETURNING			
		From 1 Year Ago	From 2 Years Ago	From 3 Years Ago	From 4 Years Ago
1942-43	<i>80</i>				
1943-44	100	40			
1944-45	100	55	20		
1945-46	100	50	25	10	
1946-47		50	25	10	5

NOTE.—The trap series is represented by **boldface** figures, to be read horizontally from left to right; the return series is represented by *italic* figures, to be read diagonally from left to right.

The difference between a trap series and that which we are here calling a *return series*, a series used by Leopold *et al.* (1943) to compute longevity and population turnover in ring-necked pheasants, is shown in table 26. The per cent of annual decrease in a population is here referred to as the *annual mortality rate*. The per cent of the population surviving from any 1 year to the year following is the *survival rate*. The *survival index* is the average of the survival rates for the first 3 years after banding.

Mortality

Survival rates or mortality rates in waterfowl may be computed from banding data by using either trap returns of survivors or band recoveries from dead birds. Reliability of calculations in either case increases as the number of bandings increases.

Mortality rates in the Horseshoe Lake flock were calculated from data obtained from both trap returns and band recoveries.* In juvenile-banded birds, mortality rates for the first year following banding were computed from age ratios derived from trapping and from census data.

Mortality Calculated From Trap Returns.—Mortality rates of the Horseshoe Lake flock as obtained from trap returns were derived both from returns of birds banded as juveniles, and therefore

* In the computations included in tables 34-41, band recoveries from the breeding grounds are not included because often the years of recovery are not known with certainty.

Table 27.—Approximate mortality of juvenile Canada geese during the first year after banding (year 0-1) at Horseshoe Lake, as determined by censuses and age ratios from trapping, 1943-44 through 1946-47.

YEAR CLASS	ESTIMATED SIZE OF HORSESHOE LAKE FLOCK*	PER CENT JUVENILES IN TRAP CATCHES (SEE TABLE 24)	CALCULATED NUMBER OF JUVENILES IN FLOCK	PER CENT YEARLINGS IN TRAP CATCHES (SEE TABLE 25)	CALCULATED NUMBER OF YEARLINGS IN FLOCK	PER CENT SURVIVAL OF JUVENILES OF PREVIOUS YEAR
1943-44..	53,000	56.0	29,680			
1944-45..	40,500	55.1	22,316	13.2	5,346	18.01
1945-46..	29,100	36.2	10,534	25.7	7,479	33.51
1946-47..	31,000			12.0	3,720	35.31
Total...			62,530		16,545	
Average						26.46

*Method of estimating flock described on page 119. Per cent of error in censusing would be approximately the same for each year.

of a known age class, and from returns of birds of all ages, tables 27-33. They are based on the assumption that the number of individuals from each age class and banding class that return to the traps in any trapping season is approximately proportional to the total number alive of those same age and banding classes in the entire population. Thus, when trap returns in the same year of any two or more age or banding classes of geese banded in previous, successive years are expressed as percentages of each of the respective original bandings, the difference between these percentages is a measure of annual mortality. Average mortality rates in tables 30 and 33 are weighted averages based on data from bandings and trap returns in all years represented.

The method of deriving the weighted

survival series is explained in footnotes to tables 29 and 32. The difference between successive survival series figures is a measure of annual mortality.

When the numbers of geese of different but successive banding classes retrapped in any one later year are expressed as percentages of the original bandings, annual mortality rates, tables 30 and 33, can be calculated by the following formula:*

Per cent returns in year 1

Per cent returns in year 2

Per cent mortality for = $\frac{\text{Per cent returns in year 1} - \text{Per cent returns in year 2}}{\text{Per cent returns in year 1}}$

Table 28.—Trap returns of Canada geese banded as juveniles at Horseshoe Lake, 1940-41 through 1946-47.

SEASON	NUMBER OF JUVENILES Banded	RETURNS IN DESIGNATED YEAR FOLLOWING BANDING							TOTAL
		1	2	3	4	5	6	7	
1940-41	143								
1941-42	274	1							1
1942-43	619	8	2						10
1943-44	1,379	67	13	3					83
1944-45	607	87	20	7	2				116
1945-46	196	106	35	8	5	0			154
1946-47		39	56	16	7	3	2		123
Total	3,218	308	126	34	14	3	2		487

Because this method of computing mortality rates involves measuring the difference between the rates at which samples of two age or banding classes banded in successive years return to the traps in a later year, it cannot be used to compute mortality during the year of banding.

Age ratios secured from trapping at Horseshoe Lake, table 27, are perhaps sufficiently representative of the population to be useful in calculating the approximate survival of geese in their first year of life. It has been noted, however, that geese that have been attracted to the traps and banded as juveniles are more apt to return to the traps as yearlings the following year than are the geese banded as adults or yearlings. This tendency often

* Year 1 in formula represents any banding year except year of banding (as 2-3 in table 29); year 2 represents the next successive year (as 3-4 in table 29); returns for the same trapping season are used in making calculations, as 3.23 and 2.55 for 1944-45, table 29.

results in catches that are composed of disproportionately large numbers of banded yearlings in relation to the actual numbers of this age class in the untrapped portion of the population, with the result that calculated mortalities for yearlings, although seemingly very high, may be below the rates that actually occur in that age group in the unbanded segment of the population.

In table 28 the actual number of trap returns from geese banded as juveniles at Horseshoe Lake is given, and in table 29 these numbers have been converted into percentages of the original bandings. For example, 67 geese banded as juveniles in the trapping season of 1942-43 and 13 geese banded as juveniles in the season of 1941-42 were trapped in the winter of 1943-44, table 28. Expressed as percentages these returns were 10.82 and 4.74 per cent of the original bandings (619 and 274, respectively), table 29.

The survival series figures in tables 29

and 32 were derived from the weighted average per cent returns of geese of consecutive year classes, beginning with year 1-2 (first trapping season after year of banding). Tables 28, 29, and 30 include only juvenile-banded geese; tables 31, 32, and 33 include both juvenile-banded and adult-banded birds.

A more nearly accurate picture of survival in age classes than that given by table 29 begins with the 26.46 year-of-banding survival figure, table 27. Survival in subsequent years was derived from the weighted average per cent returns in table 29 through the formula explained in footnote 4 of that table; the survival series figure for the year previous to year 1-2 is assumed to be 26.46. For example, $9.57:4.17::26.46:x$; x is 11.53, the survival series figure for the year 1-2. The entire survival series is 26.46, 11.53, 3.90, 3.73, 1.99, 3.87, fig. 74. The weighted average survival rates, as calculated from this survival series by the method suggested

Table 29.—Trap returns of Canada geese banded as juveniles at Horseshoe Lake, expressed as percentages of original bandings, 1940-41 through 1946-47.

SEASON	PER CENT OF GEESE RETURNING IN DESIGNATED YEAR FOLLOWING BANDING					
	1-2	2-3	3-4	4-5	5-6	6-7
1940-41.....	—					
1941-42.....	0.70					
1942-43.....	2.92	1.40				
1943-44.....	10.82	4.74	2.10			
1944-45.....	6.31	3.23	2.55	1.40		
1945-46.....	17.46	2.54	1.29	1.82	0.00	
1946-47.....	19.90	9.23	1.16	1.13	1.09	1.40
Weighted average per cent returns ¹	9.57	4.17	1.41	1.35	0.72	1.40
Weighted survival series, no. 1 ²	51.40	22.40	7.57	7.25	3.87	7.52
Weighted average survival rates, no. 1 ³	51.40	43.58	33.79	95.77	53.38	194.32
Weighted survival series, no. 2 ⁴	43.57	14.73	14.10	7.52	14.62	—
Weighted average survival rates, no. 2 ⁵	43.57	33.81	95.72	53.33	194.41	—
Survival index, 42.92 ⁶						

¹ Total of weighted average per cent returns, 18.62. Figures in this category were derived from table 28. The total number of trap returns for each year is expressed as a percentage of the total number of bandings they represent. For example, 308 (returns for year 1-2) equals 9.57 per cent of 3,218 (bandings, 1940-41 through 1945-46); 126 (returns for year 2-3) equals 4.17 per cent of 3,022 (bandings, 1940-41 through 1944-45).

² Figures in this category were derived by finding what per cent the weighted average per cent returns for each year are of the weighted average per cent returns for all years involved (18.62). Example: for year 4-5, the figure 7.25 was derived by finding what per cent 1.35 is of 18.62. The indicated increase for year 6-7 obviously is based upon insufficient data.

³ The figure in this category for year 1-2 was derived as explained for the figure directly above it. Figures for subsequent years were derived by finding the per cent of survival from year to year, as indicated by the weighted survival series no. 1. Examples: 22.40 is 43.58 per cent of 51.40; 7.57 is 33.79 per cent of 22.40.

⁴ Figures in this series were derived by the following formula, in which a , b , and c are any consecutive years: *weighted average returns in year b: weighted average returns in year c:: survival series no. 2 figure for year a: survival series no. 2 figure for year b* (x). Example: $1.41:1.35::14.73:x$; $x=14.10$. The survival series no. 2 figure for the year previous to year 1-2 is assumed to be 100.

⁵ The figure in this category for year 1-2 was derived as explained for the figure directly above it. Figures for subsequent years were derived by finding the per cent of survival from year to year, as indicated by weighted survival series no. 2. Examples: 14.73 is 33.81 per cent of 43.57; 14.10 is 95.72 per cent of 14.73.

⁶ Average of weighted average survival rates no. 1 for the first 3 years.

Table 30.—Annual mortality rates (per cent) of juveniles in the Canada goose flock at Horseshoe Lake, 1940–41 through 1946–47. (See formula, page 173, and data in table 29, top).

SEASON	MORTALITY RATE IN DESIGNATED YEAR FOLLOWING BANDING				
	0-1 ¹	1-2	2-3	3-4	4-5
1940-41	—				
1941-42	—				
1942-43	—	52			
1943-44	82	56	56		
1944-45	66	49	21	45	
1945-46	65	85	49	—41 ²	100
1946-47	—	54	87	3	3
Weighted average mortality ³	74	56	66	4	47

¹ Figures in this column calculated from figures in column 7, table 27.
² Increase in population indicated; inadequate data.
³ Figures derived by subtracting from 100 each of weighted average survival rates mentioned in text, page 175.

in footnote 5 of table 29, are 26.46, 43.58, 33.82, 95.64, 53.35, and 194.47. The

Table 32.—Trap returns of banded Canada geese of all ages at Horseshoe Lake, expressed as percentages of original bandings, 1940–41 through 1946–47.

SEASON	PER CENT OF GEESE RETURNING IN DESIGNATED YEAR FOLLOWING BANDING					
	1-2	2-3	3-4	4-5	5-6	6-7
1940-41	—					
1941-42	1.90					
1942-43	3.48	1.27				
1943-44	9.55	4.97	4.44			
1944-45	8.33	3.57	2.49	2.22		
1945-46	15.36	3.61	1.06	1.24	0.00	
1946-47	20.97	8.44	2.36	1.16	1.68	1.27
Weighted average per cent returns ¹	9.70	4.39	2.20	1.37	0.98	1.27
Weighted survival series, no. 1 ²	48.72	22.05	11.05	6.88	4.92	6.38
Weighted average survival rates, no. 1 ³	48.72	45.26	50.11	62.26	71.51	129.67
Weighted survival series, no. 2 ⁴	45.26	22.68	14.12	10.10	13.09	—
Weighted average survival rates, no. 2 ⁵	45.26	50.11	62.26	71.53	129.60	—
Survival index, 48.03 ⁶						

¹ Total of weighted average per cent returns, 19.91. Figures in this category were derived from table 31. The total number of trap returns for each year is expressed as a percentage of the total number of bandings they represent. For example, 509 (returns for year 1-2) equals 9.70 per cent of 5,245 (bandings, 1940-41 through 1945-46); 217 (returns for year 2-3) equals 4.39 per cent of 4,939 (bandings, 1940-41 through 1944-45).
² Figures in this category were derived by finding what per cent the weighted average per cent returns for each year are of the weighted average per cent returns for all years involved (19.91). Example: for year 3-4, the figure 11.05 was derived by finding what per cent 2.20 is of 19.91. Indicated increase for year 6-7 is based upon insufficient data.
³ The figure in this category for year 1-2 was derived as explained for the figure directly above it. Figures for subsequent years were derived by finding the per cent of survival from year to year, as indicated by the weighted survival series no. 1. Example: 22.05 is 45.26 per cent of 48.72; 11.05 is 50.11 per cent of 22.05.
⁴ Figures in this series were derived by the following formula, in which *a*, *b*, and *c* are any consecutive years: weighted average returns in year *b*: weighted average returns in year *c*: survival series no. 2 figure for year *a*: survival series no. 2 figure for year *b* (*x*). Example: 1.37:0.98::14.12:*x*; *x*=10.10. The survival series no. 2 figure for the year previous to year 1-2 is assumed to be 100.
⁵ The figure in this category for year 1-2 was derived as explained for the figure directly above it. Figures for subsequent years were derived by finding the per cent of survival from year to year, as indicated by weighted survival series no. 2. Examples: 22.68 is 50.11 per cent of 45.26; 14.12 is 62.26 per cent of 22.68.
⁶ Average of weighted average survival rates for the first 3 years.

Table 31.—Total catches and trap returns of banded Canada geese of all ages at Horseshoe Lake, 1940–41 through 1946–47.

SEASON	NUMBER CAUGHT AND BANDIED OF ALL AGES	GEESE RETURNING IN DESIGNATED YEAR FOLLOWING BANDING							TOTAL
		1-2	2-3	3-4	4-5	5-6	6-7		
1940-41	315	—							
1941-42	402	6						6	
1942-43	1,036	14	4					18	
1943-44	2,329	99	20	14				133	
1944-45	853	194	37	10	7			248	
1945-46	310	131	84	11	5	0		231	
1946-47	—	65	72	55	12	7	4	215	
Total	5,245	509	217	90	24	7	4	851	

survival index, not entirely comparable to survival indices in tables 29 and 32, is 34.62.

The weighted average mortality rate for each year of life following banding can be derived from the weighted survival series after computing the per cent of

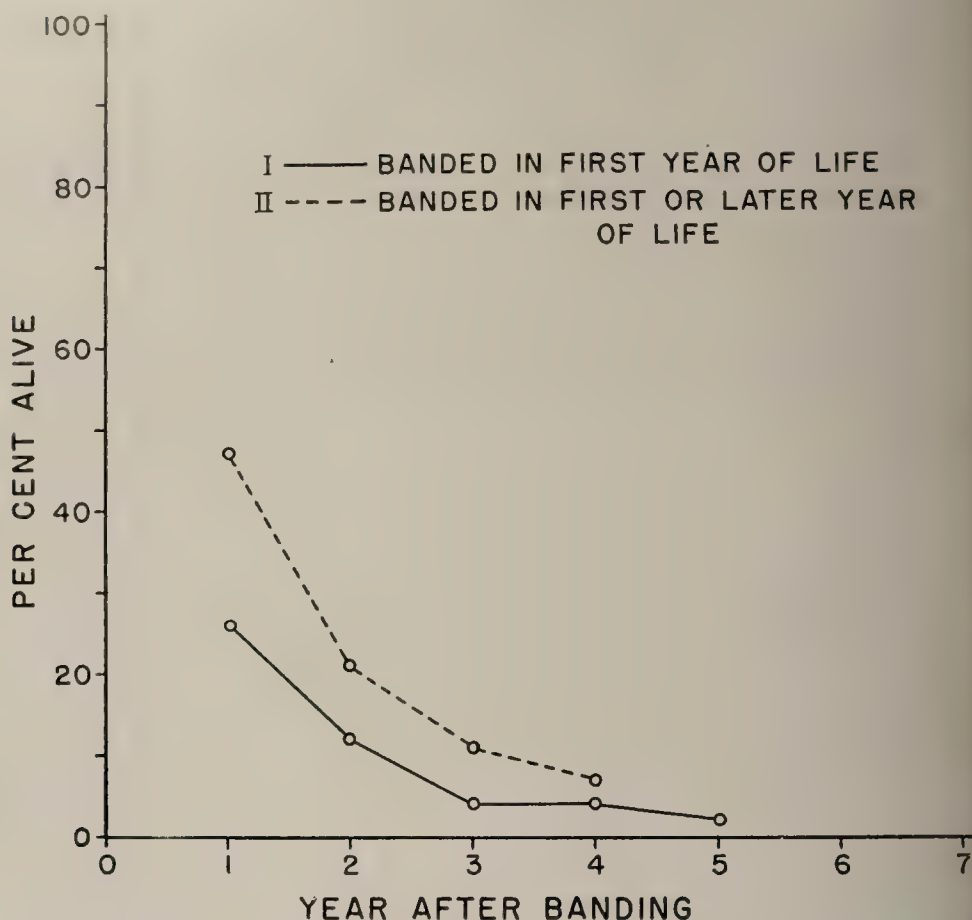


Fig. 74.—Survival of two groups of Canada geese, one banded in first year of life and one banded in first or later year of life. Curve I figures are from page 174; Curve II figures are from table 32, survival series 1.

geese remaining alive in each successive year. The survival rates cited above indicate that an average of 74 per cent of the original bandings disappeared by the end of the year of banding, 56 per cent of the survivors were lost during the second year after banding, 66 per cent the third year, 4 per cent the fourth year, and 47 per cent the fifth year, table 30.

Data on returns from banded geese of all ages, that is, the combined returns of birds banded as juveniles, yearlings, and geese of unknown age, have been treated in the manner described above, tables 31, 32, and 33. The survival series obtained, 49-22-11-7-5, table 32 and fig. 74, is believed to represent the approximate rate at which the average banding class in the

Horseshoe Lake flock disappeared during the first 5 years of life following banding in the trapping seasons 1940-41 through 1946-47. The disproportionate loss of juveniles that usually occurs, in large part from shooting, does not weight this portion of the survival series, since the series is based on the total per cent of the geese returning to the traps 1 or more years after banding. The weighted average per cent return, 9.70, table 32, of geese the first year after the year of banding necessarily represents birds that are at least $1\frac{1}{2}$ years of age.

The calculation methods discussed above leave much to be desired, particularly those involving mortality rates of the juveniles during the first year of life after

Table 33.—Annual mortality rates (per cent) in the Canada goose flock wintering at Horseshoe Lake, 1940–41 through 1946–47. (See formula, page 173, and data in table 32, top.)

SEASON	MORTALITY RATE IN DESIGNATED YEAR FOLLOWING BANDING				
	1-2	2-3	3-4	4-5	5-6
1940-41.....	—				
1941-42.....	—				
1942-43.....	63				
1943-44.....	48	11			
1944-45.....	57	30	11		
1945-46.....	76	71	—17 ¹	100	
1946-47.....	60	72	51	—45 ¹	24
Weighted average mortality ²	55	50	38	28	—30 ³

¹ Increase, instead of decrease, indicated because of disproportionate return to traps of banding class.
² Derived from table 32 by subtracting each survival rate no. 2 figure from 100.
³ Figure based on insufficient data.

Table 34.—Number of band recoveries from Canada geese banded at Kingsville, Ontario, and recovered in the states of Michigan, Wisconsin, Ohio, Indiana, Illinois, Iowa, Kentucky, Tennessee, Missouri, Arkansas, Mississippi, and Louisiana. (Autumn bandings only.)

YEAR Banded	RECOVERIES IN DESIGNATED YEAR FOLLOWING BANDING												
	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13
1925.....	(9)	6	10	6	3	4	0	0	3	0	0	0	0
1926.....	(12)	11	5	3	3	0	0	0	0	0	0	0	0
1927.....	(2)	3	4	3	0	0	0	1	0	0	0	0	0
1928.....	(7)	23	8	0	7	2	0	0	3	0	1	1	0
1929.....	(7)	13	1	4	1	0	0	1	0	0	0	0	0
1930.....	(20)	4	8	7	9	3	1	0	0	0	2	0	0
1931.....	(1)	35	26	12	3	1	1	2	3	2	0	1	0
1932.....	(21)	31	10	1	3	1	1	2	2	0	0	1	0
1933.....	(25)	24	3	2	3	3	6	1	0	0	0	0	0
1934.....	(18)	6	1	4	2	6	3	0	1	1	0	0	
1935.....	(1)	1	2	1	0	2	1	0	0	0	0		
1936.....	(1)	10	7	6	8	2	1	1	2	0			
1937.....	(9)	17	34	21	5	7	6	8	0				
1938.....	(2)	13	9	2	2	9	0	3					
1939.....	(7)	35	11	3	9	4	0						
1940.....	(32)	11	4	2	3	1							
1941.....	(2)	12	12	9	6								
1942.....	(4)	9	6	0									
1943.....	(10)	11	7										
1944.....	(6)	15											

NOTES ON TABLE 34
Numerals indicating recoveries made during the year of banding are enclosed in parentheses.
Solid horizontal lines divide this table into four 5-year periods, treated in several tables following.
Recoveries for the years above the broken horizontal line are considered complete; they are treated in table 35 and expressed graphically in fig. 75.
Figures to the left of the single vertical rule are treated in table 36 and expressed graphically in fig. 76.
Figures to the left of the double vertical rule are treated in table 40 and expressed graphically in fig. 79.
Italicized figures and those above to the next solid horizontal line are treated in table 37, and the resultant survival series is shown graphically in fig. 77.
Boldface figures and those above to the next solid horizontal line are treated in table 39, and the resultant survival series is shown graphically in fig. 78.

Table 35.—Recoveries in the Mississippi River valley of bands from Canada geese banded at Kingsville, Ontario, in the autumn, 1925–1932. The recoveries are for 12 years, including the year of banding.¹

1925-1932 BANDINGS	RECOVERIES IN DESIGNATED YEAR FOLLOWING BANDING												
	0 ²	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
Bands recovered.....	0	79	126	72	36	29	11	3	6	11	2	3	3
Bands not recovered..	381	302	176	104	68	39	28	25	19	8	6	3	0
Survival series ³	100	79	46	27	18	10	7	7	5	2	2	1	0
Survival rate ⁴		79	58	59	65	57	72	89	76	42	75	50	0

¹ Data in this table were derived from table 34; included are the sums of figures in table 34 for the period 1925–1932 in the several columns representing year of banding and years 1–2 through 11–12 following banding.

² Time of banding. The 381 in the column below represents the total of the number of bands recovered in the 12 years included in the table. No correction made for differences in times of banding in year 0–1.

³ Survival series figures are derived by finding the total number of bands recovered and then calculating what percentage the number of bands not recovered in each year is of the total number of recoveries; for example, for year 1–2, the number 176 is divided by 381 to give 46.

⁴ Survival rate figures are derived by calculating what percentage the number of bands not recovered in each year is of the number of bands not recovered in the preceding year; for example, for year 2–3, the number 104 is divided by 176 to give 59.

flock as a whole. The reasons that the banded component was not well inter-mixed were (1) the tendency of many banded individuals to use the same sector of the refuge during the season of band-

Table 37.—Recoveries in the Mississippi River valley of bands from Canada geese banded at Kingsville, Ontario, by 5-year periods, 1925–1944. The recoveries are for the year of banding and parts of the 4 years following.¹

1925–1929 BANDINGS	RECOVERIES IN DESIGNATED YEAR FOLLOWING BANDING					
	0 ²	0–1	1–2	2–3	3–4	4–5
Bands recovered..	0	37	43	19	9	3
Bands not recovered.....	111	74	31	12	3	0
Survival series ³	100	67	28	11	3	0

1930–1934 BANDINGS	RECOVERIES IN DESIGNATED YEAR FOLLOWING BANDING						
	0 ²	0–1	1–2	2–3	3–4	4–5	5–6
Bands recovered.....	0	37	56	28	16	14	6
Bands not recovered..	157	120	64	36	20	6	0
Survival series ³	100	76	41	23	13	4	0
Survival rate ⁴	—	76	53	56	56	30	

1930–1934 BANDINGS	RECOVERIES IN DESIGNATED YEAR FOLLOWING BANDING						
	0 ²	0–1	1–2	2–3	3–4	4–5	5–6
Bands recovered.....	0	85	100	48	26	20	14
Bands not recovered..	293	208	108	60	34	14	0
Survival series ³	100	71	37	20	12	5	0
Survival rate ⁴	—	71	52	56	57	41	

1935–1939 BANDINGS	RECOVERIES IN DESIGNATED YEAR FOLLOWING BANDING						
	0 ²	0–1	1–2	2–3	3–4	4–5	5–6
Bands recovered.....	0	20	76	63	33	24	24
Bands not recovered..	240	220	144	81	48	24	0
Survival series ³	100	92	60	34	20	10	0
Survival rate ⁴	—	92	65	56	59	50	

1935–1939 BANDINGS	RECOVERIES IN DESIGNATED YEAR FOLLOWING BANDING					
	0 ²	0–1	1–2	2–3	3–4	4–5
Bands recovered..	0	20	41	43	7	0
Bands not recovered.....	111	91	50	7	0	0
Survival series ³	100	82	45	6	0	0

1940–1944 BANDINGS	RECOVERIES IN DESIGNATED YEAR FOLLOWING BANDING					
	0 ²	0–1	1–2	2–3	3–4	4–5
Bands recovered..	0	54	43	22	11	3
Bands not recovered.....	133	79	36	14	3	0
Survival series ³	100	59	27	11	2	0

¹ Data in this table were derived from table 34; included are the sums of figures in table 34 for three 5-year periods, 1925–1939, in the several columns representing year of banding and years 1–2 through 5–6 following banding.

² See footnote 2, table 35.

³ See footnote 3, table 35.

⁴ See footnote 4, table 35.

¹ Data in this table were derived from table 34; included are figures obtained by adding each column of figures in each of four 5-year periods from top downward through the italicized figures. For instance, for year 3–4 in the first 5-year period, the figures 6 and 3 are added.

² See footnote 2, table 35.

³ See footnote 3, table 35.

ing, as well as during subsequent banding seasons, and (2) the tendency of some individuals to establish a trap habit that persisted in later years.

For several reasons it seemed desirable to make an "across the board" treatment of the trap data, that is, an analysis of mortality from annual random samplings of the retrapped banded survivors. Tables 28-33, referring to trap returns, should be read horizontally; they should not be read diagonally, as they would be if a single banding class were followed through the years.

A few geese banded at Horseshoe Lake winter in parts of the Mississippi flyway other than at this lake, and while some disperse to other flyways, table 4, there is no evidence that this dispersal to a different wintering range is greater during any particular year than in others, a factor that might otherwise seriously influence the validity of our survival series.

Mortality Calculated From Band Recoveries.—The survival rate measured by the use of band recoveries is based on the assumption that the unbanded segment of a population disappears at approximately the same rate as the banded segment and that year-to-year differences in the numbers of banded birds reported dead in successive years is indicative of the annual mortality of the entire population. However, unless all banding is

Table 38.—Recoveries in the Mississippi River valley of bands from Canada geese of all age classes banded at Horseshoe Lake, 1940-41 through 1944-45.

TRAPPING SEASON	RECOVERIES IN DESIGNATED YEAR FOLLOWING BANDING					
	0-1 ¹	1-2	2-3	3-4	4-5	5-6
1940-41.....	—	15	7	11	3	2
1941-42.....	—	10	10	7	1	
1942-43.....	—	40	17	10		
1943-44.....	—	39	36			
1944-45.....	—	15				
Bands recovered..	—	119	70	28	4	2
Bands not recovered.....	223	104	34	6	2	0
Survival series ² ...	100	47	15	3	1	0

¹ Year of banding; recoveries in this year not included in calculations in table.

² Survival series calculated as described in footnote 3, table 35.

Table 39.—Recoveries in the Mississippi River valley of bands from Canada geese banded at Kingsville, Ontario, in four 5-year periods, 1925-1944. The recoveries are for parts of the first 5 years following the year of banding.¹

	RECOVERIES IN DESIGNATED YEAR FOLLOWING BANDING					
	0-1 ²	1-2	2-3	3-4	4-5	5-6
1925-1929 BANDINGS						
Bands recovered..	—	56	27	12	6	4
Bands not recovered.....	105	49	22	10	4	0
Survival series ³ ...	100	46.7	21.0	9.5	3.8	0
1930-1934 BANDINGS						
Bands recovered..	—	100	47	20	12	3
Bands not recovered.....	182	82	35	15	3	0
Survival series ³ ...	100	45.0	19.2	8.2	1.6	0
1935-1939 BANDINGS						
Bands recovered..	—	76	52	28	8	2
Bands not recovered.....	166	90	38	10	2	0
Survival series ³ ...	100	54.2	22.9	6.0	1.2	0
1940-1944 BANDINGS						
Bands recovered..	—	58	29	11	9	1
Bands not recovered....	108	50	21	10	1	0
Survival series ³ ...	100	46.3	19.4	9.3	0.9	0

¹ Data in this table were derived from table 34; included are figures obtained by adding each column of figures in each of four 5-year periods from top downward through the **boldface** figures. For instance, for year 3-4 in the first 5-year period, the figures 6, 3, and 3 are added.

² Year of banding. Recoveries in this year not included in calculations in table.

³ Survival series calculated as described in footnote 3, table 35.

completed before the opening of the hunting season, the first-year recoveries will be too few and the entire survival series too high. This criticism is valid for the survival series in tables 36 and 37, in which first-year recoveries are included in the computations to make relative comparisons of survival rates.

In the computation of a survival series from band recoveries, the recoveries may be treated in either of two primarily different ways: (1) the recoveries for each year may be expressed as a percentage of the number of geese banded; or (2) the recoveries may be totaled to give the hypothetical original number of banded birds alive at the start of the first year following banding, and then the number of re-

coveries reported during each succeeding year after banding is subtracted from the number of banded geese unrecovered and presumably alive the preceding year; then the number of geese unrecovered and assumed to be alive in each year is expressed as a per cent of the total recoveries, table 35. The second method must be used for recovery data from bandings at Kingsville, Ontario, because the size of the original banding is not known with certainty and because an unknown portion of the bandings listed in table 2 were Mississippi Valley geese; presumably the

remainder represented the Southeast population.

For the purpose of comparing mortality in another segment of the Mississippi Valley population since 1925 with mortality in the Horseshoe Lake flock, recoveries of geese banded at the Jack Miner Bird Sanctuary in the autumn were used, table 34. Although band recoveries from geese of unknown age at the time of banding do not give a precise picture of population mortality in Canada geese because of the differentially high kill of the juveniles by hunters, they suffice as a basis for a com-

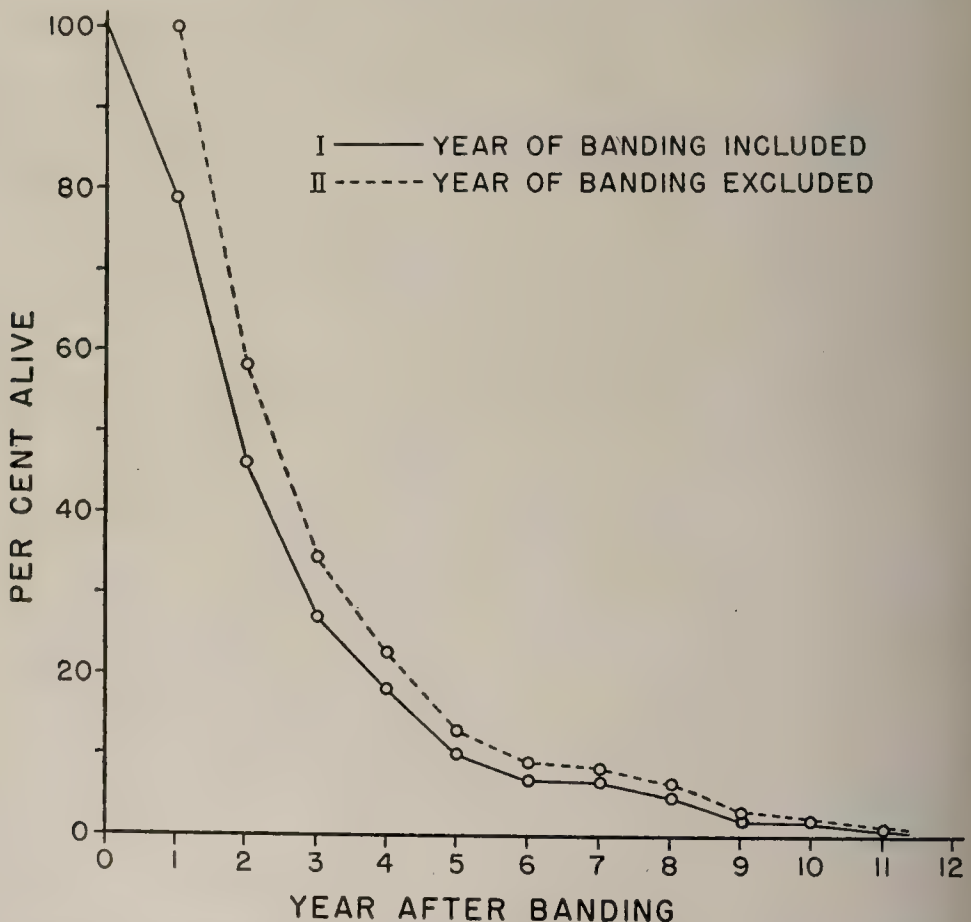


Fig. 75.—Average survival of Mississippi Valley Canada geese, as measured by band recoveries from geese banded at the Jack Miner Bird Sanctuary, Kingsville, Ontario, in the autumn, 1925–1932. Curve I includes band recoveries made during the year of banding; curve II excludes recoveries made during the year of banding. Curve I (data from table 35) starts with an expression (100 per cent) of the total number of recovered bands; curve II (data from table 41) starts with an expression (100 per cent) of the total number of recovered bands that were on geese alive at the beginning of the year following banding.

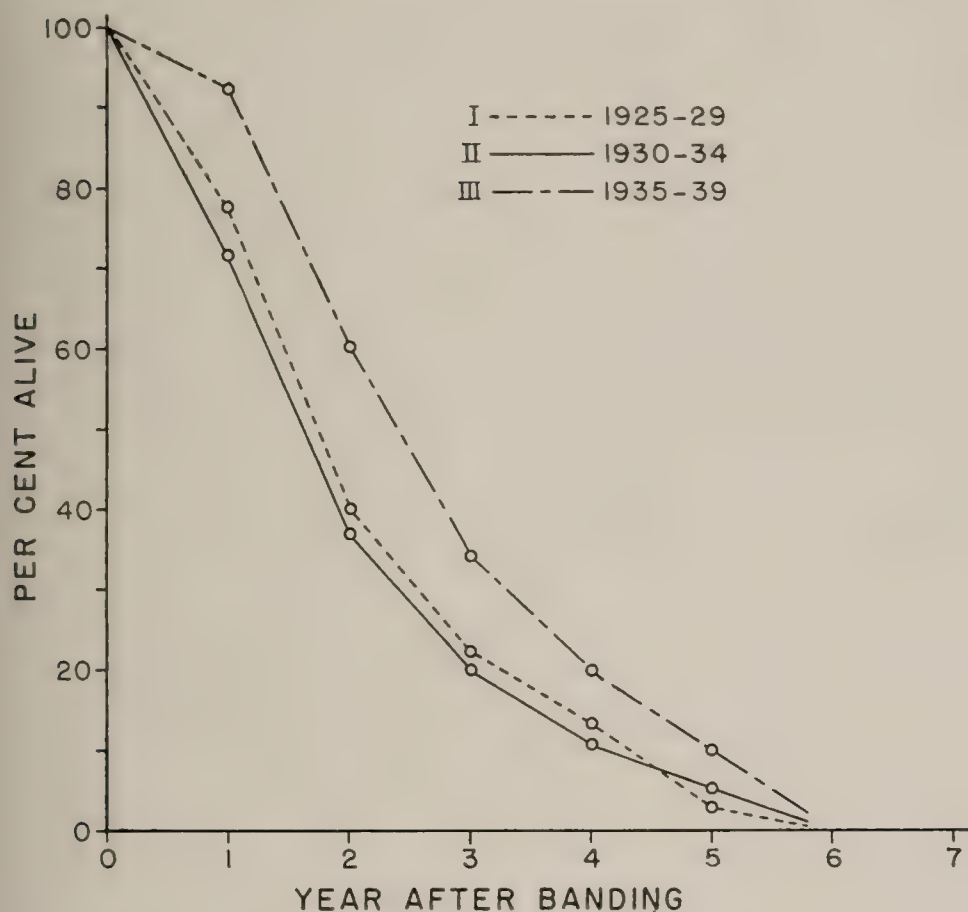


Fig. 76.—Average survival of Mississippi Valley Canada geese, as measured by band recoveries from geese banded at the Jack Miner Bird Sanctuary, in the autumn, 1925-1939. That part of each curve representing the year of banding shows a higher rate of survival than actually occurred, as in the data (from table 36), which represent the number of bands recovered and not the number of bands applied; no correction was made for the varying lengths of exposure to guns experienced by geese banded at various times in the season of banding.

parison of mortality rates in different years. As no individuals from the Miner autumn bandings have been reported shot in the Mississippi River valley later than 12 years after banding, recoveries of geese banded in 1925-1932 may be considered nearly 100 per cent complete by 1944. These data, summarized in table 35 and presented graphically in fig. 75, curve I, show that maximum survival in Canada geese in the Mississippi River valley under moderate hunting pressure is about 12 years.

Since about 93 per cent of the bands in the 12-year series were recovered by the

end of the sixth or seventh years after banding, table 35, no great error would result from basing an analysis of mortality from 1925 through 1939 on the number of banded geese reported dead by the end of the sixth or seventh years. Recoveries of birds banded in those years are grouped by three 5-year periods. These 5-year data groups are set off by horizontal lines in table 34. In table 36, they have been summarized. The survival curves based on these data are shown graphically in fig. 76.

In order to compare the survival of geese banded at the Miner Sanctuary in

1940-1944 with the survival achieved by geese banded by the Miners in previous years, it was necessary to use an incomplete band-recovery series, derived from table 34, as explained in a footnote to table 37. The groupings for this analysis are summarized in table 37 and the computed survival curves are shown in fig. 77.

First-year survival data obtained from recoveries of geese banded at the Miner Sanctuary in the autumn are not an accurate representation of average first-year survival for Mississippi flyway geese as a whole. Whereas most bandings of waterfowl yield the greatest number of recoveries during the year of banding, the

largest number of recoveries from Miner bandings have been received in most instances the year following the year of banding, table 34. One reason for this situation may be that the geese that are trapped and banded represent those that remain at the sanctuary the longest; this explanation is supported by migration data. Late south-bound migrants tend to remain longer in the more northerly sectors of the autumn and winter range than do the early migrants. Furthermore, most of the geese banded at the Miner Sanctuary in the autumn are trapped in November and December, when the hunting season in the northern and central zones of the

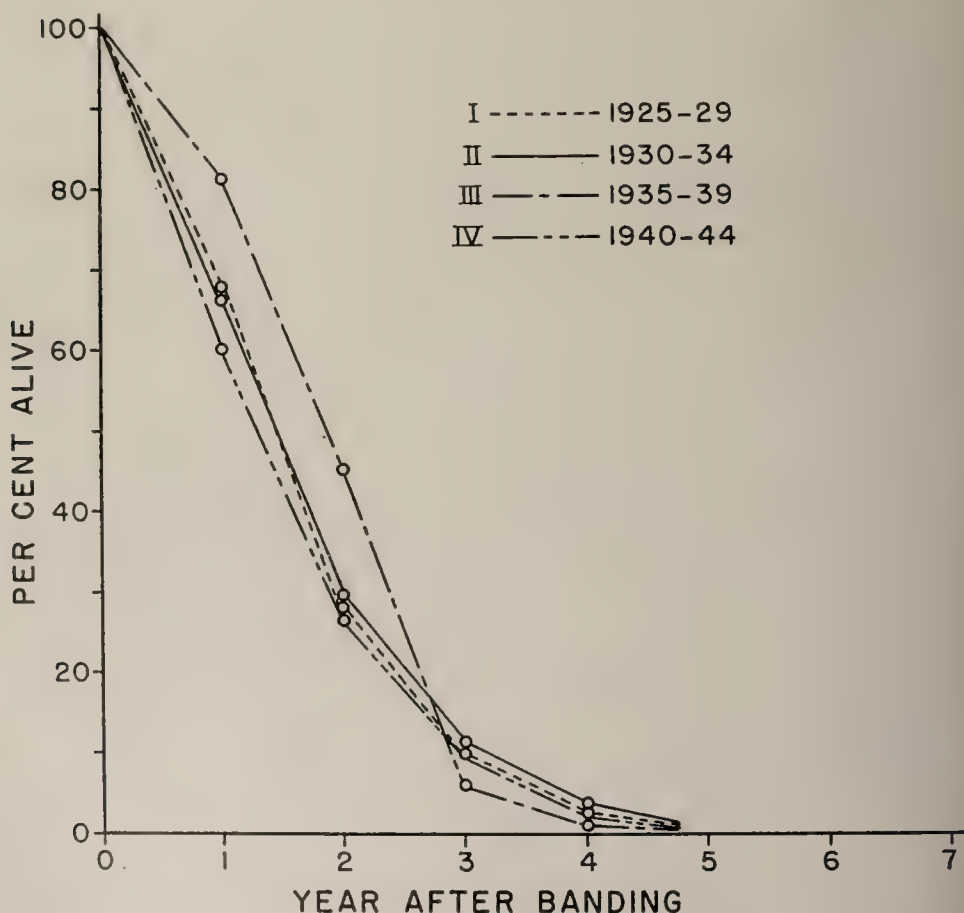


Fig. 77.—Comparative survival of Mississippi Valley Canada geese in four 5-year periods. Curves are based on band recoveries from geese banded at the Miner Sanctuary in the autumn (data from table 37, which include recoveries in year of banding). Curves start with an expression (100 per cent) of total number of bands recovered, not total number placed on geese.

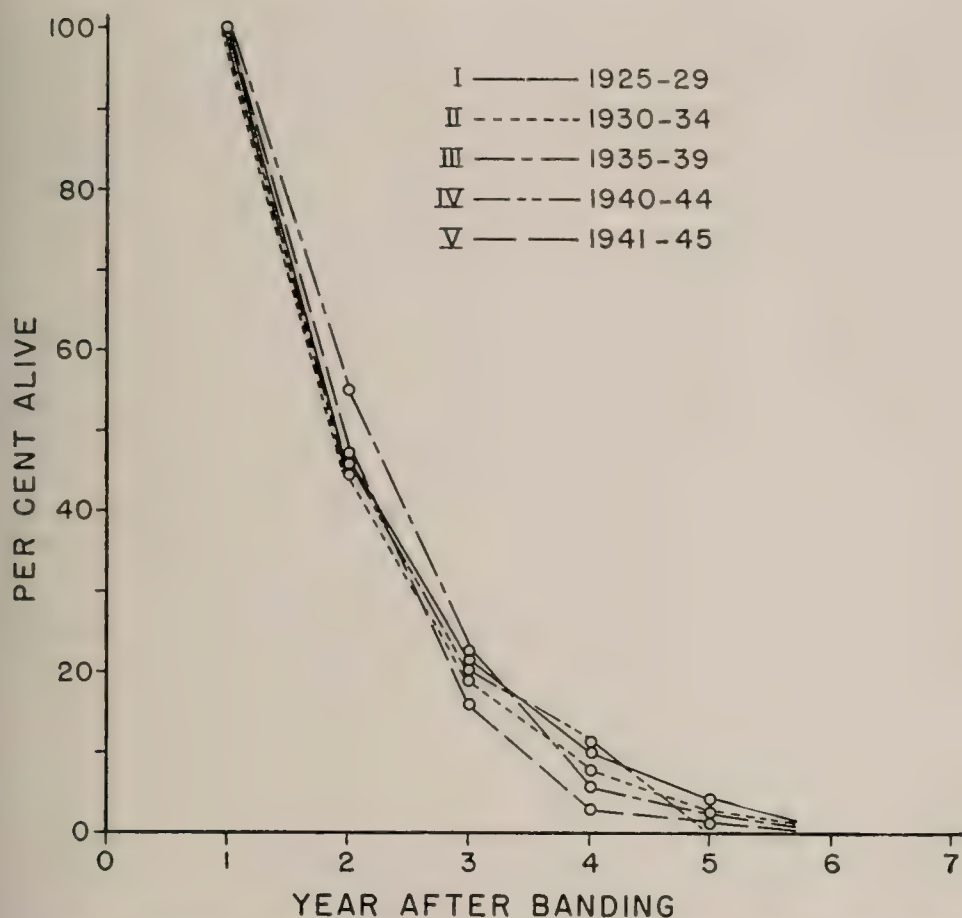


Fig. 78.—Comparative survival in three 5-year periods of Mississippi Valley Canada geese that were at least $1\frac{1}{2}$ years old (the year after being banded). Curves I-IV are based on data from table 39, bandings at Kingsville, Ontario. Curve V is based on data from table 38, bandings at Horseshoe Lake. All curves start with an expression (100 per cent) of the total number of recovered bands that were on geese alive at the beginning of the year following banding.

Mississippi flyway is at least half over. Nevertheless, these data demonstrate something of the magnitude of the *relative* differences of survival of the various quinquennial groupings, either graphically or expressed as survival indices.

Because the Canada goose population wintering at Horseshoe Lake constitutes a somewhat different representation of the Mississippi Valley population than do the geese banded in the autumn at the Miner Sanctuary (demonstrated by the fact that geese banded at Horseshoe Lake are shot farther north on the breeding

range than are geese banded at Kingsville, Ontario, fig. 7), it is of interest to compare the band-recovery data from these two banding stations through the season 5-6 after banding, the last season for which data are available for both stations.

When this comparison of mortality rates is made, it is desirable to omit recoveries made during the season of banding, since the time of banding, the location of the banding station, and the circumstances immediately following banding are not comparable. The recovery data from the Horseshoe Lake flock are

given in table 38 and the recovery data from the Miner bandings for a comparable number of years are summarized in table 39. The survival series derived from tables 38 and 39 are presented graphically in fig. 78.

Inspection of the curves in fig. 78 reveals that the differences between curves I and IV are not so great as between comparable curves shown in fig. 77. The probable explanation is that all recoveries shown graphically in fig. 78 represent geese at least $11\frac{1}{2}$ years old, whereas the survival series that includes recoveries during the season of banding are in part from juvenile

geese. Since the latter age class is far more vulnerable to shooting than older geese, recoveries from a banded population that includes juveniles would naturally reflect more sensitively the severity of hunting losses in various seasons. For this reason curve V in fig. 78, which is based on data presented in table 38, does not adequately reflect the tremendous and disproportionate kill of juveniles in the vicinity of Horseshoe Lake from 1943 through 1945.

In table 40, recoveries of bandings, 1925-1939, complete through season 6-7 after banding, but omitting recoveries the

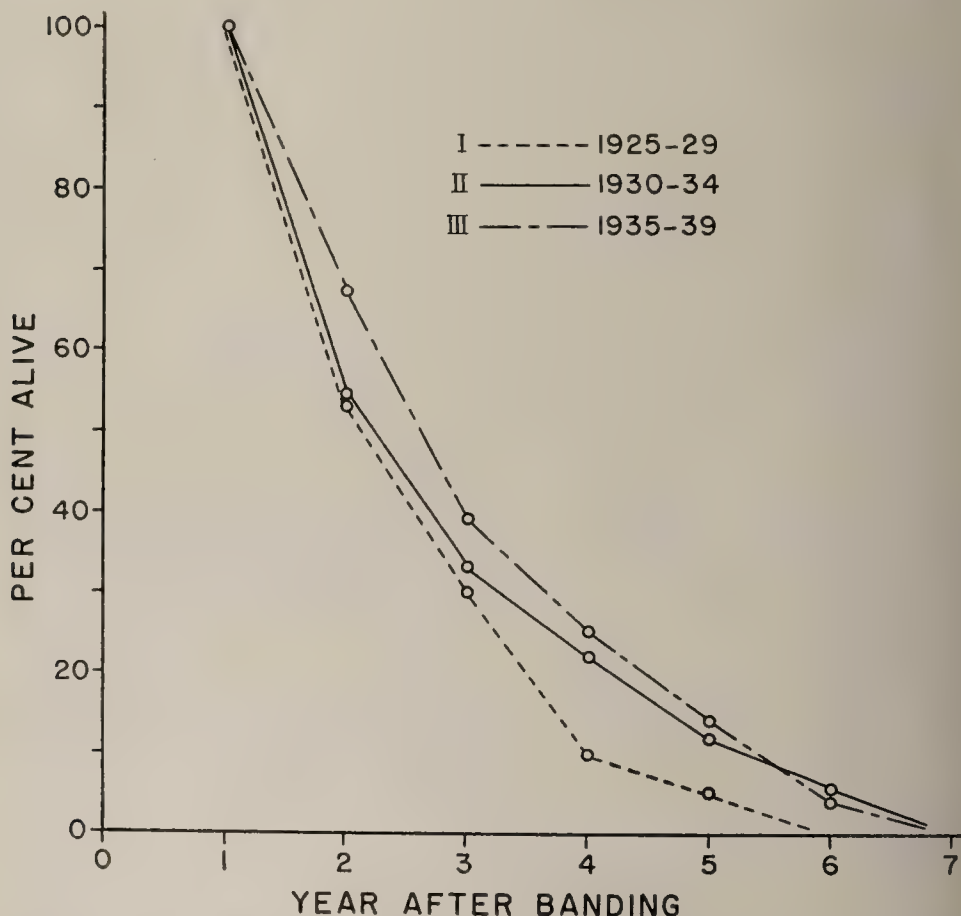


Fig. 79.—Comparative survival (in four 5-year periods) of Canada geese that were at least $11\frac{1}{2}$ years old (the year after being banded). Curves are based on recovery data from table 40, bandings at Kingsville, Ontario. All curves start with an expression (100 per cent) of the total number of recovered bands that were on geese alive at the beginning of the year following banding.

Table 40.—Recoveries in the Mississippi River valley of bands from Canada geese banded at Kingsville, Ontario, in three 5-year periods, 1925–1939. The recoveries are for the first 6 years following the year of banding.¹

	RECOVERIES IN DESIGNATED YEAR FOLLOWING BANDING						
	0-1 ²	1-2	2-3	3-4	4-5	5-6	6-7
1925-1929 BANDINGS							
Bands re- covered....	—	56	28	16	14	6	0
Bands not recovered...	120	64	36	20	6	0	0
Survival series ³	100	53.3	30.0	10.0	5.0	0	0
Survival rate ⁴ ...	—	53.3	56.3	33.3	50.0	0	0
Survival in- dex, 47.6 ⁵ ...							
1930-1934 BANDINGS							
Bands re- covered....	—	100	48	26	20	14	12
Bands not recovered...	220	120	72	46	26	12	0
Survival series ³	100	54.5	32.7	20.9	11.8	5.5	0
Survival rate ⁴	—	54.5	60.0	63.9	56.5	46.2	0
Survival in- dex, 59.5 ⁵							
1935-1939 BANDINGS							
Bands re- covered....	—	76	63	33	24	24	8
Bands not recovered...	228	152	89	56	32	8	0
Survival series ³	100	66.7	39.0	24.6	14.0	3.5	0
Survival rate ⁴	—	66.7	58.6	62.9	57.1	25.0	0
Survival index, 62.7 ⁵							

¹ Data in this table were derived from table 34; included are totals obtained by adding the figures in each column of three 5-year periods, 1925–1939, years 1-2 through 6-7.

² Year of banding. Recoveries in this year not included in calculations in table.

³ Survival series calculated as described in footnote 3, table 35.

⁴ Survival rate calculated as described in footnote 4, table 35.

⁵ Average of first 3 years of survival rate.

year of banding, are treated by 5-year groups. These data are shown graphically in fig. 79. Survival indices from these recovery data can be regarded as a fair approximation of average survival during at least the first 3 years of adult life after banding. However, the most nearly accurate survival index for 3 years of adult life (actually from at least 1½ to at least 4½ years of age) after banding, 60.7 per

cent, is obtained from the complete recovery series, table 41 and fig. 75, curve II. A survival index for years of this study, an index calculated from trap returns rather than band recoveries and for the Horseshoe Lake flock, 48.03, is obtained from the data given in table 32. For purposes of comparison, survival indices obtained from the data discussed above are summarized in table 42. The converse of a survival index is a mortality index, that is, the average of mortality rates for 3 consecutive years. Mortality indices also are given in table 42.

Mortality data are available for only a few other game species. Leopold *et al.* (1943) have shown that in an unshot pheasant population a year class is reduced to zero in 5 years, and that the average annual mortality of a year class is about 70 per cent, a mortality rate that compares closely with that found for the Hungarian partridge and for the California quail by Emlen (1940). In contrast to these rates, annual mortality in many passerine birds appears to be between 50 and 55 per cent (Farner 1945).

Leopold *et al.* (1943) have stated that after a pheasant reaches its first winter its chance of survival apparently does not improve with age; that is, the survival rate is constant. The data presented by Buss (1946) do not agree with this conclusion. Because geese are longer lived than pheasants and acquire wariness and habits of survival value with age, it seems reasonable to assume that greater experience and learning with increased age in Canada geese would improve the individual's chance of survival. Band recoveries, as well as observations of living birds, have already shown that, insofar as shooting is concerned, juveniles have a greater mortality rate than adults. To discover whether mortality rates of Canada geese undergo change with increasing age after the first year of life, recoveries in table 41 have been plotted logarithmically, fig. 80. Losses prior to 1½ years of age are indicated in fig. 80 by a dotted line. The curve is "completed" only in order to obtain visual appreciation as to what its approximate shape might be if it were based on adequate and complete data for the entire life span. The curve suggests some improvement of survival with in-

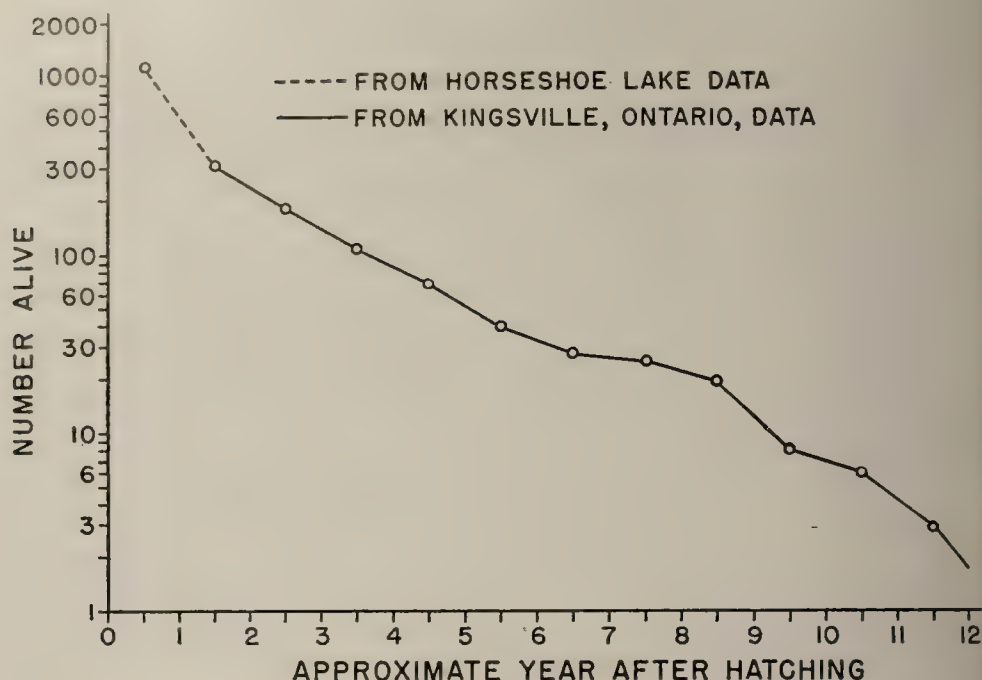


Fig. 80.—Approximate survival curve (semilogarithmic) for the Canada goose population of the Mississippi flyway, as indicated by age ratios and censuses of geese at Horseshoe Lake, 1940–1947, and by band recoveries from geese banded at Kingsville, Ontario, 1925–1932. Because geese banded at Kingsville were of unknown age at time of banding, the curve may be only a rough approximation of the actual survival curve.

creasing age after about the fifth or sixth year of life, but the evidence is not conclusive. The decreasing reliability of data 5 or 6 years after banding, the varying take by hunters from year to year, and the fact that the data represent, in

the first place, geese of unknown ages tend to obscure the actual picture.

Longevity

Geese as a group are noted for being long lived, particularly in captivity;

Table 41.—Recoveries in the Mississippi River valley of bands from Canada geese banded at Kingsville, Ontario, in the autumn, 1925–1932. (Data from table 34.) This table differs from table 35 in that here the band recoveries from the year of banding are not included.

1925-1932 BANDINGS	RECOVERIES IN DESIGNATED YEAR FOLLOWING BANDING											
	0-1 ¹	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
Bands recovered.....	—	126	72	36	29	11	3	6	11	2	3	3
Bands not recovered.....	302	176	104	68	39	28	25	19	8	6	3	0
Survival series ²	100	58	34	23	13	9	8	6	2	2	1	0
Survival rate ³	—	58	59	65	57	72	89	76	42	75	50	0
Survival index, 60.7 ⁴												

¹ Beginning of year following year of banding. The 302 in this column represents the total of the number of bands recovered after this time in the period included in the table.

² See third footnote, to table 35. In the table above, recoveries in the year of banding are excluded, and the total number of recoveries considered is 302 instead of the 381 in table 35.

³ See fourth footnote to table 35.

⁴ Average of first 3 years of survival rate.

Table 42.—Survival indices of Canada geese banded at Kingsville, Ontario, in the autumn, and at the Horseshoe Lake Game Refuge.

BANDING SEASONS	AGE AT BANDING	BANDING STATION	SURVIVAL INDEX*	MORTALITY INDEX	KIND OF DATA USED	REFERENCE
1925-1932.....	All ages.....	Miner Sanctuary.....	60.7	39.1	Band recoveries.....	Table 41
1925-1929.....	All ages.....	Miner Sanctuary.....	47.6	52.4	Band recoveries.....	Table 40
1930-1934.....	All ages.....	Miner Sanctuary.....	59.5	40.5	Band recoveries.....	Table 40
1935-1939.....	All ages.....	Miner Sanctuary.....	62.7	37.3	Band recoveries.....	Table 40
1940-1947.....	All ages.....	Horseshoe Lake.....	48.0	52.0	Trap returns.....	Table 32
1940-1947.....	Juveniles.....	Horseshoe Lake.....	34.6	65.4	Trap returns and age ratios.....	Page 175

* These survival indices are an average of survival rates for years 1-2 through 3-4 and were derived as indicated in the "Reference" column of this table. They are slightly lower than if derived from a complete band-recovery series. The mortality index is derived by subtracting the survival index from 100.

Flower (1925) records that two Canada geese lived to be 29 years of age and a third 33 years. McAtee (1924) learned of one pair of Canada geese that were mated for 42 years and another pair for over 20 years. Wilfrid (1924) reported a gander he believed to be at least 40 years old at the time of the bird's death, and Leffingwell (1890) reported "as a matter of history" a captive bird that was killed when it was 80 years old. Doubtless there are other records in the literature that compare with these. Several instances of Canada geese, once used for decoys and later kept as pets, that attained ages of at least 20 years have been reported to the authors of this paper.

In the wild, few Canada geese approach these ages. The greatest age attained by a wild Canada goose, to our knowledge, is at least 22 years. This goose was banded at the Miner Sanctuary in the spring of 1923 and retrapped in the spring of 1932 and again in the spring of 1944. The life span of the average wild Canada goose after banding, however, proves to be only a few years, generally less than 3, but as Austin (1942) has pointed out, "It is of little importance biologically speaking how long members of a species live providing their life span is long enough for a generation to reach and maintain sexual maturity in order to duplicate the achievement of its predecessor."

In most instances, our data are inadequate to compute average longevities with accuracy. The complete recovery series, table 35, are of limited usefulness, since the geese involved were of unknown age when banded. These data are further complicated by the fact that the number of recoveries during the season of banding are not representative of usual first-year mortality. Average longevities calculated from data collected for the present study would be misleading. While average longevities derived from adequate data would serve ideally to compare the survival of individuals of different bandings, for the present study the survival indices shown in tables 29, 32, 40, 41, and 42 are useful and are more appropriate. From these indices and from other data, it seems obvious that few Mississippi Valley Canada geese live longer than 3 or 4 years after being banded.

An approximation of the longevity of juvenile geese banded at Horseshoe Lake in the years of this study may be obtained through computations beginning with the following formula:

$$S = \frac{f_1 y_1 + f_2 y_2 + f_3 y_3 \text{ etc.}}{N}$$

S stands for average survival after banding; f_1, f_2 , etc. represent, for each age-class involved, the mortality frequency in each of successive years as computed from the survival series on page 174: 26.46, 11.53, 3.90, 3.73, 1.99 (mortality frequencies;* 73.54, 14.93, 7.63, 0.17, 1.74); y_1, y_2 , etc. represent the number of years (1 through 5) following banding applicable to each mortality frequency; N represents the sum of the mortality frequencies. The mean death date of geese banded at Horseshoe Lake was about midway between mean banding dates.† Hence, the value calculated for S, 1.4 years, is corrected by subtracting 0.5 to give average survival after banding, 0.9 year.

As juveniles at Horseshoe Lake were about 0.5 year old when banded, this figure is then added to 0.9 to give the average longevity, 1.4 years. Thus, it might be said that the average banded juvenile goose and presumably the average juvenile in the unbanded Horseshoe Lake population in the years of this study did not live long enough to produce one brood of young.

DISCUSSION

It is axiomatic that the sound management of a wildlife species must in the last analysis rely on carefully gathered scientific data. Waterfowl studies usually concern migratory species for which it is difficult to secure adequate data from all parts of the range. The range of most waterfowl species is immense, and some populations shift their distribution within a flyway from year to year because of changing food, water, and weather conditions.

The aim of most broad studies of waterfowl species probably would be to gather

* Derived by subtraction: 100.00-26.46, 26.46-11.53, 11.53-3.90, etc.

† Mean banding date about December 1.

information that would allow management of the species concerned on a flyway basis, as recently suggested by Gabrielson (1944). Because Canada geese tend to exhibit a greater adherence to their ancestral range than do ducks, management by flyways for this species is more suitable than it would be for most other waterfowl. In fact, the fairly restricted range of the various Canada goose populations in eastern North America, as shown earlier, suggests the need for certain management measures for individual population ranges rather than for an entire flyway. Although additional information concerning the Mississippi Valley goose population is needed, enough is now available to permit this population to be managed primarily as individual population units.

Status

In 1946, 14 states of the Mississippi flyway (Michigan, Wisconsin, Minnesota, Ohio, Indiana, Illinois, Iowa, Kentucky, Tennessee, Missouri, Mississippi, Alabama, Arkansas, and Louisiana) were closed to the hunting of Canada geese. The closed season of an entire flyway was the first of its kind in the history of this species of waterfowl. The only similar actions ever taken were those closing the shooting seasons on snow geese and brant in the Atlantic Coast states. Snow-geese hunting has been prohibited there since 1931, and brant hunting for more than half of the years since 1933.

The closed season on Canada geese in the Mississippi flyway in 1946 was believed necessary for a number of reasons: an alarming decrease in the number of these geese in the Mississippi flyway from 1940 to 1945, as indicated by January inventory data; markedly increased kills beginning in 1939, particularly in the region of Horseshoe Lake; a disproportionate kill of juvenile birds and an apparent decreased productivity in 1945, as indicated by research at Horseshoe Lake.

The peak number of geese at Horseshoe Lake dropped from about 50,000 in 1943-44 to 26,000 in 1945-46. That this decrease represented a real decrease in the flyway population and was not due to bypassing of the area by flocks is shown not only by flyway censuses but by band-recovery records. These records indicate

that since 1932 many of the geese that formerly used the Mississippi River from Cairo, Illinois, to Baton Rouge, Louisiana, have concentrated in a much smaller area centering on Horseshoe Lake, probably because of the refuge there and the large amount of grain available to the geese.

Known bags and careful estimates of kills indicate that, in the years just previous to 1946, an average of about 20 per cent of the Canada goose population wintering at Horseshoe Lake was bagged annually, and that the total annual kill in the area averaged about 27 per cent of the population. In view of the fairly low productivity of the Canada goose, it is obvious that a reasonable kill in this area was greatly exceeded. Population declines at Horseshoe Lake and in the Mississippi flyway as a whole showed that flock mortality from all causes combined had been excessive, and, as hunting losses are one type of mortality that can be controlled, it was evident that closing the entire flyway to shooting was the most effective management measure that could have been employed.

Evidence of increased shooting pressure on Canada geese in years just previous to 1946 is illustrated by the survival curves, fig. 77, representing data computed from band recoveries from geese banded at the Jack Miner Bird Sanctuary, Kingsville, Ontario. These data show that the annual survival rate for that portion of the population migrating through the Kingsville area was lower in the 5 years beginning in the fall of 1940 than in any comparable period in the previous 15 years, fig. 77. Chiefly responsible for this lower survival rate were the heavy kills made at Horseshoe Lake; band recoveries show that the survival rate of the Horseshoe Lake flock was well below the average for the entire Mississippi Valley population. In fact, the survival series for the Horseshoe Lake flock was lower during the period 1940-1945 than it was in the entire Mississippi Valley population in the years in which baiting and the use of live decoys were permitted, tables 10, 37, and 38.

Moffitt (1935) was concerned over the future of a flock nesting in California when he realized an 11.5 per cent first-season recovery rate from his bandings. Unpublished studies by Cecil S. Williams

of the United States Fish and Wildlife Service at the Bear River marshes, Utah, indicate that the Great Basin population he dealt with could show a first-year band-recovery rate of 16 per cent and a total band-recovery rate of 25 per cent and still increase. Total recoveries from Horseshoe Lake bandings were at only about half the rate of total recoveries reported for the Great Basin, but other data indicated a heavy kill rate and a decline in the Horseshoe Lake population in the years just previous to 1946. While Williams' data establish the fact that the Canada goose could withstand heavy shooting losses in the Great Basin, conditions vary too widely in the various flyways to predict on the basis of data from one area (Utah) what the conditions are in another (Horseshoe Lake).

Interpolating from fig. 74, curve I, which is based on a survival series obtained for the Horseshoe Lake flock, it appears that only about 16 per cent of the juveniles reaching Horseshoe Lake

during the period of field work for this study lived long enough to see a brood of their young on the wing.

When a major portion of the annual kill of a Canada goose flock is at the expense of one age group, data on the total number of birds bagged do not reveal the true impact of the kill upon the total population. At Horseshoe Lake the juveniles made up the major part of the kill in the period covered by this study, tables 43 and 44. In the autumn of 1943, the juveniles made up 56 per cent of the population, while 91 per cent of the hunter's bag consisted of juveniles. In that year, 37 per cent of the juvenile population at Horseshoe Lake was bagged. The following year, the 1943 generation (then yearlings) comprised only about 29 per cent of the total adult birds. The effect of this differential kill is also shown by trap-age ratios of banded survivors in later years. In table 43, returns for the years 1943-1947 of geese banded during the autumn and winter season previous to

Table 43.—Juvenile-adult ratios of Canada geese at Horseshoe Lake, 1942-43 through 1946-47, arranged to show the effect of a differential kill on survival. (See table 23.)

SEASON	JUVENILES PER 100 ADULTS Banded	JUVENILES PER 100 ADULTS IN BAG	NUMBER RETURNING TO TRAPS 1 YEAR LATER			
			Age Class	Num- ber	Per Cent of Original Banding	Yearlings Per 100 Adults
1942-43..	153	259	Juvenile	67	10.82	137
			Adult	32	7.92	
1943-44..	145	1,053*	Juvenile	87	6.31	56
			Adult	107	11.26	
1944-45..	246	942	Juvenile	106	17.46	173
			Adult	25	10.08	
1945-46..	172	410	Juvenile	39	19.90	87
			Adult	26	22.81	

* Although this figure is based on a smaller sample than in most other years, field observations and data collected subsequently indicate that it is a close approximation of the actual kill ratio.

Table 44.—Calculated kill of juvenile Canada geese at Horseshoe Lake, 1942-43 through 1945-46, exclusive of crippling losses.

SEASON	NUMBER OF JUVENILES IN FLOCK (SEE TABLE 27)	TOTAL KILL, ALL AGES	PER CENT OF BAG MADE UP OF JUVENILES	CALCULATED NUMBER OF JUVENILES IN BAG	PER CENT OF TOTAL JUVENILES IN FLOCKS BAGGED BY HUNTERS NEAR HORSESHOE LAKE
1942-43.....	32,450	6,529	72.1	4,707	14.5
1943-44.....	29,680	12,062	91.3	11,013	37.1
1944-45.....	22,316	7,807	90.4	7,058	31.6
1945-46.....	10,534	5,244	80.4	4,216	40.0

each of these years are given. In the autumn of 1942, when only 2.59 juveniles were shot for every adult, the survival rate of juveniles was evidently favorable to this age class as 10.82 per cent of the total banded juveniles returned to the traps in the following year as compared with 7.92 per cent of the adults, or a ratio of 1.37 juveniles to 1.0 adult.

In contrast to this survival picture is the highly differential kill that occurred in 1943 when the ratio of juveniles to adults shot at the hunting clubs surrounding the refuge was 10.53 to 1.0, table 43. The next year the return to the traps was only 0.56 juvenile (then yearling) to 1 adult. Despite the fact that juveniles bore the brunt of the kill in 1944, table 44, the net loss to the juvenile segment of the population was somewhat less, with the result that the ratio of juvenile (then yearling) to adult returns in the traps a year later, in 1945-46, was 1.73 to 1.0, table 43.

A relatively high kill of juveniles coupled with a year in which productivity is low is almost certain to place a goose population in a hazardous position. Banding at Horseshoe Lake indicated a decrease in productivity in 1945 from the productivity in 1944, table 43. The relatively small number of young produced in 1945 may have been related in part to the cold weather in the spring of that year; the productivity of mallards also was greatly reduced in that year. A depressive effect on the intensity of mating or on nesting success in many species of birds has been attributed to late and cold springs. The following species said to be affected thus might be cited: Canada goose (Johnson 1947); arctic tern (Lack 1933); eiders and loons (Bird & Bird 1940); moor hen (Huxley 1932); and house wren (Kendeigh 1942).

However, it is conceivable that part of the decrease in productivity in 1945 may have been apparent rather than real. Undoubtedly juveniles contribute a larger proportion of the kill during migration than do the adults, but the extent to which shooting north of the Horseshoe Lake Game Refuge is selective of juveniles is not known. Because the kill between the refuge and the Canadian border in 1945 was much larger than usual, the age ratios

in the southward-bound flocks may have been significantly altered by shooting in that particular year.

The subject of cycles in waterfowl is still largely an unexplored field. It does not appear to be known generally that, in the arctic, geese, ducks, and loons may be subject to nonbreeding years (Manniche 1910, Bertram, Lack, & Roberts 1934, Bird & Bird 1940). Keith (1937) writes, ". . . 1936 was a 'non-breeding year' [in Northeast Land, Spitzbergen Archipelago] when large numbers of Ducks and Geese failed to nest; and in other parts of the Arctic it had always before been found that the Divers [loons] were also affected by these years and that of them too only a small proportion were breeding." As nonbreeding of waterfowl has been reported only from high arctic areas, it is debatable whether the Canada goose populations dealt with here are similarly affected.

At present, low productivity in blue geese and snow geese appears to be confined to summers in which inclement weather directly affects the success of nesting (Soper 1930). In the opinion of Berry (1939), "climate is of the utmost importance in limiting the survival rate of goslings on the northern breeding grounds."

A year of low productivity in Canada geese should be of particular concern to the administrators who seek to influence the kill by hunting regulations, for the reason that the young birds bear a double responsibility. Being more vulnerable to shooting than the adults, they must contribute a disproportionate share of the kill, and, secondly, they must survive in sufficient numbers to help reproduce an equivalent of the annual loss in the breeding population. Even in a year when the production of young was not significantly low, 1943, shooting losses in the Horseshoe Lake area were so severe and so greatly at the expense of the juveniles that only a small proportion of this generation survived to reach the minimum breeding age of 2 years.

Management

What can be done to insure the future of the Mississippi Valley geese? Until recent years, two prime measures for con-

serving waterfowl, hunting regulations and refuges, have been fairly successfully used in the management of this group. As applied to the population of geese dealt with in this report, it is apparent that these measures were not very effective in the period of field work.

In Canada.—Several factors minimize the need for any immediate change in measures relating to the Mississippi Valley population while in Canada. The relatively inaccessible nature of the Canadian breeding grounds insures adequate protection for the flock during the actual breeding season.

The kill in Canada is not excessive, and a reduction of the early spring kill on the breeding grounds would be difficult because much of this kill is virtually necessary for the survival of native Indians. Furthermore, our kill and population data indicate that the annual rate of kill (the percentage of birds taken from the returning population in the spring) by the Indians is relatively constant. In general, only when there is an actual increase in

the Canada goose population does a significant increase in the number of these geese bagged by Indians occur. This relatively constant relationship is evidence that the goose kill by natives cannot be considered the direct cause of any considerable population decrease that might be reported in the United States from any of the annual January inventories.

In the United States.—In 1944 and 1945, when season bag limits were imposed for Alexander County, Illinois, table 10, it was a relatively easy matter to limit the kill of geese in the Horseshoe Lake area to approximately the predetermined figures. The facility with which the day-to-day kill can be tallied is perhaps the outstanding advantage of encouraging a portion of the flock to utilize the refuge there. The season bag limit in the above instances was determined by the trend of the population in prior years, but, to be fully effective, management should anticipate future trends based upon the current composition of the population. With the data at hand on the Canada

Table 45.—Calculated losses and reproductive gains for the Horseshoe Lake Canada goose flock between the autumn of 1944, and the autumn of 1945.¹

CLASSIFICATION	TOTAL ADDED (YOUNG PRODUCED)	TOTAL LOST	BALANCE (TOTAL SURVIVING)
Flock arriving at Horseshoe Lake in the autumn of 1944 (includes 6,885 yearling and older females).....			40,500
Number lost from hunting at Horseshoe Lake (includes 525 yearling and adult females).....		10,550	
Maximum number flying north in spring (includes 6,360 females older than 1½ years of age).....			29,950
Kill by Indians in the Hudson-James Bay area ² (includes 277 females 2 or more years of age) ³		2,100	
Natural losses for year at 18 per cent of 40,500 (includes estimated 1,000 adult females) ⁴		7,290	
Total yearlings and adults alive after breeding season (includes 5,083 adult females).....			20,560
Number of young brought to flying stage (3 per adult female).....	15,189		
Approximate total at start of autumn migration.....			35,749
Kill by hunters in flyway north of Horseshoe Lake (at 6 per cent of southward flight) ⁵		2,135	
Number calculated to arrive at Horseshoe Lake in 1945.....			33,614
Actual number to arrive at Horseshoe Lake in 1945 (inventory figure, January, 1946, plus total hunting loss in area).....			29,100

¹ In most cases calculations are based on actual data, in others on estimates.

² Proportional share of total kill suffered by the Horseshoe Lake flock.

³ Vulnerability of yearlings 2.8 times that of older geese; kill of adult females should not exceed 13 per cent of the total loss.

⁴ The loss rate from natural causes tends to be inversely related to the losses from hunting.

⁵ The kill of Canada geese between the Canadian border and Horseshoe Lake was particularly heavy in 1945; hence, the actual kill for that area probably exceeded 6 per cent of the southward flight. For reasons explained in footnote on page 150, the actual kill rate in this area in most years is probably closer to 8 or 10 per cent of the southward flight.

goose in the Mississippi River valley, it is possible to arrive at a practical estimate of the maximum kill that can be tolerated.

A method by which management of the Mississippi Valley population might proceed is best illustrated by a concrete example, table 45. Similar calculations based on sex and age ratios from trapping, and made by the authors in the spring of 1945, forecast a decreased population for the autumn of 1945. Censuses during the autumn and the inventory of January, 1946, proved the accuracy of this prediction.

Since the autumn flight in any year depends to a large extent on the production of young in the spring of that year, it is necessary to know the approximate number of breeding females and to have some measure of the nesting success on the breeding grounds to predict the autumn flock population with reasonable accuracy. Inventory on the breeding grounds would be difficult because of the nature of the terrain, but the use of planes would aid tremendously in such work. For the present, and until more data are available, the average productivity of the population might be calculated on the basis of three young (brought to flying stage) per adult female.

If the flock population has been fairly stable for several years or is on the increase, a bag of 10 per cent of the number wintering in the Horseshoe Lake area might prove to be within the limits of what the flock could stand without decreasing in size. Even this kill might be too high if kills north of Horseshoe Lake were unusually large in a given autumn, if nesting success was low the previous spring, or if sex and age ratios were seriously unbalanced. When the population is very low, the kill of a single bird constitutes overshooting.

A reduction in the crippling loss would allow the season bag limit in the Horseshoe Lake area to be increased. The number of geese crippled and lost to hunters each year in the area is needlessly high. An estimate of cripples not retrieved and soon dying is placed at 30 per cent of the number of geese bagged. Certain administrative measures can be taken to reduce the per cent of cripples not retrieved. For instance, adequate spacing of pits to

reduce competition among hunters would materially aid in reducing crippling losses. But a large share of the responsibility will rest with the hunter himself, who must restrain the natural desire to "give a high one a ride." Some hunters hope to bag geese with greater ease by using magnum shotguns. However, it is open to debate whether more geese are bagged than crippled by such guns because of the out-of-range shooting their possession encourages. At least in one instance a 10-gauge magnum shotgun is known to have failed to live up to its owner's expectation; a tally of empty casings from this shotgun in one pit, presumably fired to bag the limit of two geese, was 22, as against the average of 9 cartridge casings per hunter for all pits inspected.

It is clear from tables 15 and 10, showing kill and hunting regulations in the Horseshoe Lake area, that hunting restrictions were not always successful in reducing the kill to the desired extent, but, if various measures instituted to lower the annual kill had not been taken, it is probable that a large proportion of the Canada geese using the Horseshoe Lake area would have been shot by the end of 1945.

Under normal conditions, the duration of the hunting season can be expected to show a fairly direct relationship to the kill, but, when the natural wariness of the geese has been reduced, as at Horseshoe Lake, the length of the hunting season may show no correlation with the kill, figs. 52 and 53.

Pirnie (1939) has emphasized that "Changing habits of these birds [Canada geese] may create new hazards for them and require even more stringent regulations." The behavior of the Horseshoe Lake flock in recent years and its relation to shooting has already been discussed, but it should again be emphasized that restrictions alone cannot be expected to safeguard it.

Refuges form an important part of our system for the preservation of waterfowl. Whether or not any individual refuge proves of value will depend to a certain extent upon its management and also upon its size. Leopold (1931) stated the chief problem in regard to the Horseshoe Lake Game Refuge soon after this refuge was

created. "The question of whether public refuges should be surrounded by public shooting grounds is frequently debated. Horseshoe Lake in Alexander County, Illinois, is a good place to study the question."

Twelve years after this statement was published the answer was forcibly given by Gabrielson (1943). "Because of its [Horseshoe Lake Game Refuge] attractiveness to Canada geese, small size, lack of food, and peculiar relation to surrounding lands, it has become a slaughter pen rather than a refuge."

The breakdown in wariness that occurred was perhaps more serious to the future of the Horseshoe Lake flock than the reduction in its size. The steps believed necessary to re-establish wildness in the flock were as follows: (1) Establish refuge areas on the nearby islands and bars of the Mississippi River or on lands adjacent to the river; (2) disperse the geese from Horseshoe Lake to these bars and islands; that is, drive them back to their original habitat; (3) insofar as possible, reduce contact between human beings (both the public and refuge personnel) and the geese.

In the past years in which the geese used both the river bars and the refuge, they retained their natural wildness; coincident with their almost complete dependence on the refuge for food and grit, they lost much of their wildness. The river refuge might act as a final sanctuary for the flock should it be disturbed for any reason at Horseshoe Lake, and ideally it should contain the bulk of the flock at most times.

Canada geese will feed by moonlight, at daybreak, or at dusk, if they are disturbed while feeding during the day. This fact may offer a partial solution to the Horseshoe Lake problem. If the geese were permitted to feed at the Horseshoe Lake Game Refuge only during the hours of dawn and dusk, the re-establishment of wildness might occur and with it a reduction in the rate of kill. We have a precedent for such a course of action in the operation of the Miner Sanctuary, where the geese feed only in the early morning hours and at dusk, spending the remainder of their time roosting out on Lake Erie.

State regulations just previous to 1946

prohibited the placing of shooting pits within 75 to 150 yards of the boundary of the Horseshoe Lake Game Refuge. This buffer zone, which was intended to allow the geese to attain safe heights before reaching the shooting pits and blinds was unquestionably insufficient, since many of the geese leaving the refuge encountered shot pellets 75 yards away from the first line of pits. Although the Miner Sanctuary consists of only 400 acres and supports an even greater density of geese than is ever experienced at Horseshoe Lake, excessive kills have not occurred near this Canadian refuge in late years. Responsible in part for the small kills reported in the vicinity of the Miner Sanctuary is a buffer zone that surrounds the ponds and feeding grounds for a distance of a mile. When geese leave the refuge, they have sufficient space in which to gain altitude before passing over the shooting grounds.

The present food resources of the Horseshoe Lake Game Refuge are insufficient to winter more than 20,000 geese, and probably only 15,000 can be accommodated to best advantage. When the corn crop and wheat browse on the refuge are exhausted, and sometimes before this occurs, the flock feeds on unharvested and waste grain and on the green plants of winter wheat in fields of the surrounding countryside—occasionally at a considerable loss to farmers who do not rent their fields to hunters. Unless the flock is broken up and scattered to other areas in the flyway, the local food conditions must be improved, either through the acquisition of more land or by an artificial feeding program. The artificial program is wholly undesirable unless it is carried out on an isolated tract of land. On the other hand, the development of a river refuge would certainly increase the flock's usage of natural foods—the grasses, sedges, and switch willows on which the geese formerly fed.

The present size of the Horseshoe Lake Game Refuge is woefully inadequate for the geese using the area, as experiences there and elsewhere have demonstrated. A program involving purchase of additional lands has been planned by the State Department of Conservation for several years, but has been blocked by the inflated prices of lands in the area—inflated

prices resulting in part from the commercialization of goose hunting.

Census data showed that, between 1942 and 1945, the Canada goose in the Mississippi River valley suffered a marked decline in population. Kill records showed an increase in the annual bag beginning in 1939, and banding data revealed a concurrent decrease in goose survival for the same period. The conclusion must be reached that the Mississippi Valley Canada goose population was shot too heavily in that period and that stringent protection was necessary to insure perpetuation of this population.

PRESENT SITUATION

The time lapse between completion of the field work reported here and publication of this article has been sufficient to permit an evaluation of some of the measures recently taken to assure the future of the Canada goose population of the Mississippi River valley. The decision to close the valley to Canada goose hunting in 1946 was based partly on evidence gained from banding that the geese wintering at the Horseshoe Lake Game Refuge were suffering unprecedented losses from hunting and were being killed at a rate far greater than the flock could stand and still maintain its numbers. In addition was the evidence from annual inventories that the flyway population was at an alarmingly low level.

In 1947, the shooting of Canada geese was again permitted in the Mississippi River valley, but on a restricted scale. The season opened on November 4 and closed on December 3. The bag limit was reduced to one bird per day and the possession limit was also one bird. To insure against a return of heavy kills in the Horseshoe Lake region, an area in the region totaling approximately 15,000 acres was declared closed by proclamation of the President of the United States with the joint support of the Governor of Illinois. By this action, a buffer area, roughly 2 miles in depth, was created around the Horseshoe Lake Game Refuge. In 1948, the hunting season opened on October 29 and closed November 27. During this 30-day season, hunters were permitted to bag two Canada geese per

day and were allowed a possession limit of two birds.

The response by the geese to greater protection has been most heartening, their comeback demonstrating both that the kill by hunters in the United States was a major suppressive factor on the population, and that this population, given opportunity, possesses strong recuperative powers. With a capital investment of 49,000* birds in the Mississippi flyway in the winter of 1945-46, interest in the form of 1946 reproduction was reinvested as capital gain by virtue of the closed season. Inventory in January, 1947, revealed a capital gain of approximately 25 per cent, table 7. This recovery by an almost bankrupt population so encouraged the committee on regulations that a dividend, in the form of an open season, was declared permissible for the autumn of 1947 and again for the autumn of 1948. The dividend in the Horseshoe Lake area in 1947 was 1,644 geese bagged by hunters; in 1948 it was 2,587 geese bagged by hunters. In addition to this number, other geese, estimated at 2,000, were shot illegally within the buffer area closed to hunting outside the refuge. We do not have the data at hand to show what the profits were to hunters in other states in the flyway, but that the goose business could afford the dividends is shown by the recent summary of capital stock given in table 46.

The recovery made by the Mississippi Valley population has not gone unnoticed by the Indians who trap and hunt on the breeding grounds before the actual commencement of nesting. In August, 1949, the senior author learned at Fort Albany that the Indians there had observed more geese in the spring of 1949 than at any other time in recent years. Similarly, questionnaire answers received from Raymond M. Alaine of Weenusk, September 21, 1949, stated that the Indians at that post had not seen as many geese in any other years of the last 10 as they did in the fall of 1948.

Future management of the Horseshoe Lake flock by the United States Fish and

* This figure includes geese from western Louisiana, birds that possibly belong to the Eastern Prairie population and that should not be included in the Mississippi Valley population. Hence, it exaggerates the size of the Mississippi Valley population for 1945-46.

Table 46.—Population of Canada geese in the Mississippi River valley in 1947-48 and 1948-49, from January inventory, except as noted.

STATE OR OTHER AREA	SEASON	
	1947-48	1948-49
Michigan.....	5,000	6,000
Wisconsin.....	4,200	4,760
Indiana.....	1,679	7,449
Illinois (total).....	57,205	90,414
Mason County.....	—	960
Horseshoe Lake.....	—	46,000
Craborchard Lake, William-		
son County.....	—	30,000
Lyerly Lake, Union County.....	—	12,450
Miscellaneous areas.....	—	1,004
Kentucky.....	1,500	7,200
Mississippi.....	5,500	7,250
Tennessee.....	2,500	9,450
Arkansas.....	9,000	12,000
Missouri.....	—	5,000*
Louisiana.....	10,000	10,000
Total.....	96,584	159,523

* Most of these geese were a part of the flock wintering in the Horseshoe Lake area.

Wildlife Service and the Illinois Department of Conservation envisions the breaking up of this concentration and dividing it among four other refuge areas: Craborchard National Wildlife Refuge, Williamson County, Illinois; Lyerly Lake State Refuge and Public Shooting Grounds, Union County, Illinois; the Mingo National Wildlife Refuge, Missouri; and the Kentucky Woodlands National Wildlife Refuge bordering the Tennessee River south of Paducah, Kentucky. To implement the dispersal of geese from Horseshoe Lake, planes, guns, bombs and various other pyrotechnic devices were used to frighten the geese in 1947, 1948, and 1949. That this dispersal program is meeting with success is evident from the data presented in table 46. Provided with these other areas, an ample food supply, and adequate legal protection, the Canada goose population in the Mississippi valley faces a future that seems assured for some years to come.

SUMMARY

1. The Horseshoe Lake Wildlife Refuge, located at the southern tip of Illinois near Cairo and created in 1927 by the Illinois Department of Conservation, totals approximately 3,700 acres.

2. Soon after the refuge was formed, increasing numbers of Canada geese, decoyed from their traditional wintering grounds along the Mississippi River by the food and protection offered, began to use this refuge. In most recent winters the refuge has attracted about 50 per cent of the Mississippi Valley Canada goose population. With the increase in the size of the flock at the refuge, there was a loss of wariness on the part of the geese, accompanied by a tremendous increase in the annual kill.

3. In the eastern half of the United States there are two subspecies of Canada geese. The easternmost race, *Branta canadensis canadensis*, comprises the geese of the North Atlantic population. The other race, *Branta canadensis interior*, which breeds principally west, south, and east of James and Hudson bays, is composed of four subgroups, each of which constitutes a separate flyway population. The four subgroups are as follows: the South Atlantic, the Southeast, the Mississippi Valley, and the Eastern Prairie.

4. The main breeding range of the Mississippi Valley geese is believed to lie within the western limits of the Paleozoic Basin west of James Bay and south of Hudson Bay. The majority of the nesting geese of this population are found in relatively restricted areas of the vast, low-lying, muskeg-covered plain of the region.

5. Aerial observations revealed that the type of muskeg attracting the greatest numbers of geese is one that is studded with potholes of a few acres to about 30 acres in size, so closely grouped that often only a narrow strip of land or floating vegetation separates one from another.

6. Most nesting pairs of Mississippi Valley geese are concentrated in production centers, but, as most of these production centers are of considerable size, scattered nesting, with one or two pairs to a small lake, seems to be the rule west of James Bay and south of Hudson Bay.

7. Before the southward migration of Mississippi Valley geese begins, about August 15, some family groups and small flocks begin a series of local flights, the termini of which are favored feeding grounds along the west coast of James Bay and the south coast of Hudson Bay, the tundra of Cape Henrietta Maria and the coastal marsh of Akimiski Island. The

tundra of Cape Henrietta Maria is favored because of the quantity of berries usually available there.

8. At least half of the Mississippi Valley geese do not fly to the coastal areas before migrating, but leave directly from their muskeg breeding grounds and strike south on a broad front. These are believed to be the geese that cross the Canadian border into eastern Minnesota and the upper peninsula of Michigan.

9. While probably at least a few Canada geese in migration pass over most areas of the Mississippi flyway each year, band recoveries and observations indicate that the following routes are most frequently used: from the Miner Sanctuary to Horseshoe Lake via Lake St. Mary, the Wabash and Ohio rivers; from Saginaw Bay southwest across the lower peninsula of Michigan to the W. K. Kellogg Bird Sanctuary area and the lower Kalamazoo River; southward along both shores of Lake Michigan. Migration through Wisconsin is principally in the eastern half of the state. The west shore of Lake Michigan is followed by appreciable numbers of geese. Two other routes appear to be favored: (1) the valley of the Wisconsin River; (2) Green Bay south to Lake Winnebago, the flight probably splitting south of Lake Winnebago, one section going to the Lake Geneva area, the other following the Rock River valley. Migration through Illinois appears to take place on a fairly broad front although the Illinois River valley is particularly favored.

10. Band-recovery data indicate that turnover in the population wintering at Horseshoe Lake is negligible. Geese that are decoyed into this refuge usually remain there for the rest of the season.

11. A portion of the Mississippi Valley geese migrating through the Kingsville, Ontario, region do not visit the Horseshoe Lake Refuge but by-pass it to the east, probably via the Tennessee River, and winter on the lower Mississippi.

12. The northward migration in spring is more nearly on a directly north and south axis than routes taken in the autumn. The flights of Mississippi Valley geese that stop at the Miner Sanctuary in the autumn do not reappear there in the spring in appreciable numbers; presumably they return to the breeding grounds by a more westerly

route. The spring flights through the Kingsville region are comprised chiefly of South Atlantic geese.

13. Autumn migration of Mississippi Valley geese occurs over a 3-month period; the last geese to reach Horseshoe Lake in appreciable numbers arrive in early December. Much of the late flight represents the exodus of geese from the Miner Sanctuary when feeding there is curtailed.

14. The southward movement of the Canada geese from the breeding grounds may be compared with a segment of the concentric waves produced by an object striking the surface of a body of water. Geese that leave the breeding grounds earliest are believed to winter in the most southerly areas of the flyway. Those that leave the breeding grounds last are believed to winter in the most northerly areas of the wintering grounds.

15. In spring, the first flocks generally arrive on the breeding grounds between April 15 and 25, 2 to 3 weeks before the breakup of the major rivers.

16. Winter concentrations of Canada geese occur in the region of Kingsville, Ontario, westward to southern Wisconsin, and south to the Gulf Coast.

17. Although the Canada goose is widely reputed to be an extremely wary and difficult species to hunt, the behavior of this species at Horseshoe Lake in recent years has contradicted this reputation. Believed responsible for the high vulnerability of Canada geese to shooting in the vicinity of this refuge are the psychologically pacifying effect of large numbers of geese at rest on a relatively small area; the frequent sight of man in a benign role; and the decreased mobility of the flock when food is abundant on the refuge, as well as on adjacent hunting areas.

18. Goose hunting in Illinois, once a sport carried out in widely scattered areas of the state, is now confined largely to the Illinois River valley and the Horseshoe Lake region.

19. In the period 1944 through 1947, the kill of Canada geese of the Mississippi flyway by Canadian Indians is computed to have been between 4,000 and 5,500 or from about 8 to 10 per cent of the number of birds that attained the breeding grounds in the spring. Approxi-

mately 25 per cent of the total number of Mississippi Valley Canada geese bagged in recent years have been taken by Indians.

20. The waterfowl kill made by the Indians of the James Bay region is sometimes vital to actual survival of the Indians. Blue geese and snow geese greatly outrank the Canada goose in importance during the fall hunt along the coastal marshes; in spring, when the Indians are trapping inland along the rivers and creeks, the principal kill of Canada geese occurs, while relatively few blue geese and snow geese are shot at this time.

21. The restocking of beaver in some areas of the Canadian goose breeding range is beginning to relieve some of the hunting pressure on Canada geese.

22. The kill in the Horseshoe Lake area first began greatly to exceed what the flock could stand in 1939 when a kill of 17,300 geese was made. The average number of geese bagged in the Horseshoe Lake area in the autumns of 1939 through 1945 was about 9,800. In the autumns of 1943, 1944, and 1945 the bag amounted to 23, 19, and 18 per cent, respectively, of the number of geese that arrived at the refuge in those years.

23. The annual bag of geese in Illinois in areas other than Horseshoe Lake averaged approximately 1,100 birds in the period covered by this report.

24. Next to Illinois, Michigan made the largest kills of Mississippi Valley geese, 1938-1944; the annual bag was probably between 1,000 and 3,000 birds.

25. Bag inspections at hunting clubs near Horseshoe Lake showed that juvenile geese made up a high percentage of the total kill, 1940-1945. In 1943, juveniles were about eight times as vulnerable to hunting as adults.

26. Crippling losses among geese at Horseshoe Lake in recent years are estimated to have been equivalent to about 30 per cent of the annual bag.

27. Causes of death among Canada geese at Horseshoe Lake include lead poisoning (from ingestion of lead pellets), bound crop (perhaps a result of lead poisoning), tracheitis, and aspergillosis.

28. Sex ratios obtained from trapping geese at Horseshoe Lake show that there were slight, but statistically significant, larger numbers of males than of females

in the juvenile and adult age classes, 1940-1946. Bag-inspection figures showed no significant preponderance of either sex in either age class, 1940-1945.

29. Nesting success of geese is not appreciably affected by the Canadian Indians, since the bulk of the kill is made in early spring before geese have begun to nest. Foxes may have a slight effect on nesting success when their other prey species, which appear to be cyclic, are low in numbers.

30. In 7 years of trapping and bag inspection at Horseshoe Lake, the age ratios obtained varied from 57 to 204 juveniles per 100 older geese. In 1944-45, trapping indicated that 55 per cent of the population consisted of juveniles. Trapping in the following year indicated that the proportion of juveniles had dropped to 36 per cent.

31. Average flock size, computed from frequency counts of flocks of nine or fewer geese on the wintering grounds, may provide a quick means of appraising breeding success of geese in the previous spring.

32. Low survival of Canada geese banded at the Jack Miner Bird Sanctuary, 1940-1944, is believed to have been brought about chiefly by the tremendous increase in the kills made in the region of Horseshoe Lake.

33. Mortality data calculated from trapping and band-recovery figures show that the Horseshoe Lake flock had a lower survival rate during the period of this study than did comparable banding classes from the Miner Sanctuary.

34. Mortality indices, the average of mortality rates for three years after banding, provide a possible basis for comparing mortality between different populations and banding classes of geese.

35. Survival data for the Horseshoe Lake flock, 1941-1945, indicate that the average juvenile did not live long enough to produce a brood of young.

36. In 1946, no open hunting season on Canada geese was permitted in the Mississippi River valley. In 1947, shooting on a restricted scale was permitted.

37. Increased protection of the Mississippi Valley Canada geese plus certain other management practices resulted in an appreciable gain in the population by the fall and winter of 1948-49.

APPENDIX A

THE SOUTHEAST POPULATION

ONE of the important findings from our study of the Jack Miner banding data, as they relate to the Horseshoe Lake problems, is the existence of a distinct and heretofore unrecognized group of Canada geese that winter in the inland areas of Virginia, North Carolina, South Carolina, Georgia, and Alabama and on the Gulf Coast of Florida. Because management of the Mississippi Valley goose population should be guided to some extent by a knowledge of neighboring goose populations, it seems desirable to include in this paper a brief summary of the breeding and wintering ranges, as well as the migration paths, of the Canada geese of the newly defined group, to which we have given the name Southeast population.

Breeding Range

To date there have been no recoveries of Horseshoe Lake goose bands in the Moose River district of James Bay or at the extreme south end of this bay, while fair numbers of bands have been recovered in that region from geese banded at the Jack Miner Bird Sanctuary near Kingsville, Ontario. Large numbers of Miner bands from the autumn flight have been recovered in the inland portions of the southeastern states. It appears from band recoveries that the Southeast geese nest from the country drained by the Moose River, south and east to the Nottaway or Rupert river country. In an area north of the Moose River, the breeding grounds of these geese merge with those of the Mississippi Valley population; east of the Nottaway River, or Rupert River, they merge with the nesting grounds of the South Atlantic geese, most of which migrate through the Kingsville area only in spring.

Census data on the flyway of the Southeast population are meager. Because the scattered flocks were not recognized as components of this distinct population, their significance was lost in the usual method of lumping census figures by states. Population figures presented below are from three

sources: letters to Jack Miner from local sportsmen or officials; personal conversation with W. P. Baldwin, Jr., United States Fish and Wildlife Service biologist, stationed at Port Wentworth, Georgia; and records in the files of the Division of Refuges, United States Fish and Wildlife Service. Following is a summary of the wintering grounds of the Southeast population, as indicated by band recoveries and other data.

Migration Routes

In the autumn migration, the range of the Southeast population overlaps that of the Mississippi Valley population between James Bay and the Miner Sanctuary. At the latter point, however, band recoveries indicate that the birds of the Southeast population split off from the Mississippi Valley population and fan out south and southeast over a number of courses. The paucity of recoveries between the Miner Sanctuary and the eastern and southern slopes of the Appalachian Mountains suggests that most of the geese of the Southeast population make few stops en route to their wintering quarters.

The routes taken by these geese on their northward migration are probably mainly to the west of their autumn migration paths, as band recoveries show that comparatively few of the birds retrace their autumn flight through the Kingsville, Ontario, region.

Winter Concentrations

The wintering grounds of the geese of the Southeast population lie mainly in the Piedmont region east and south of the Appalachian Mountains, and in some parts of the coastal plain. The wintering range can be better understood if the distribution of the recoveries from the southeastern states in figs. 12-21 is compared with the physiographic features of these states shown in fig. 81. Band recoveries show that geese resort to nearly every river of appreciable size that dissects the Piedmont and the coastal plain, but that the numerous reservoirs are particularly favored. The coastal

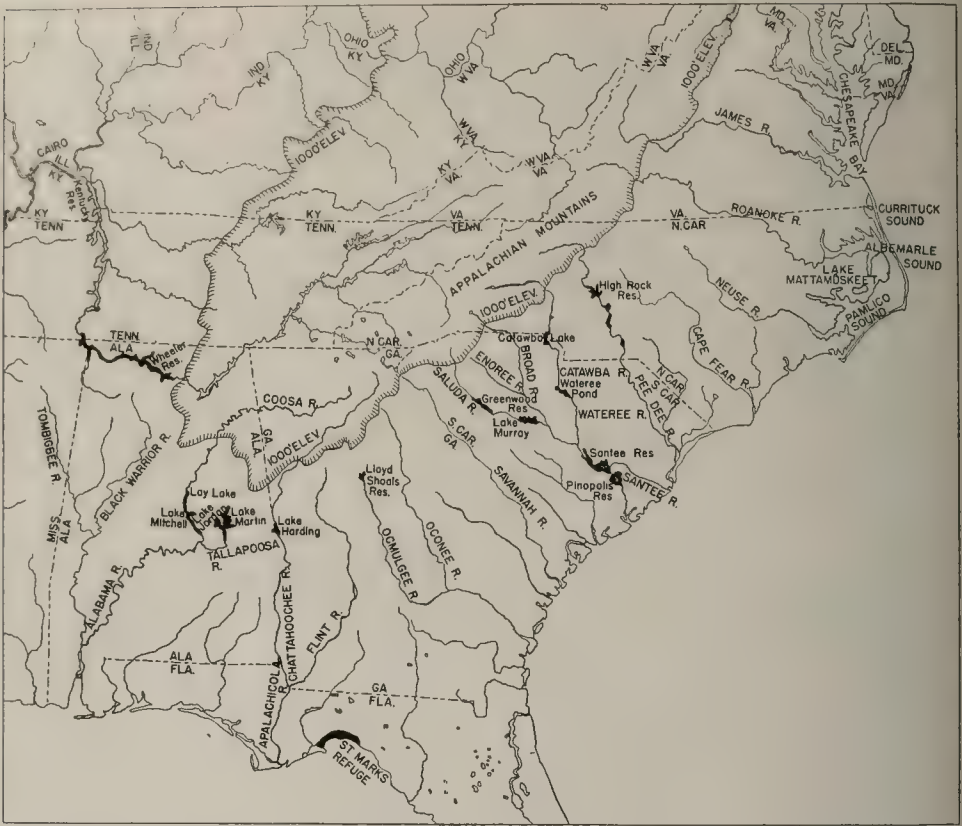


Fig. 81.—Map of the wintering grounds of the Southeast Canada goose population.

wintering range of the South Atlantic geese and the inland wintering range of the Southeast population are clearly indicated in figs. 6, 12, and 14-21.

Virginia.—Band recoveries from Canada geese banded at the Miner Sanctuary in the autumn indicate that the Southeast flyway geese wintering in Virginia concentrate in certain counties bordering the James River: chiefly Fluvanna, Goochland, Henrico, and Charles City. To a lesser extent these geese use the Mattaponi, Pamunkey, Roanoke, and Rappahannock rivers.

In a letter to Jack Miner, January 8, 1945, A. W. Smith of Richmond, Virginia, stated that about 2,000 geese frequented the James River, and another flock of about 1,500 were to be found on the Pamunkey River. As many as 15,000 geese have spent the winter in the region of Hopewell, Prince George County, according to A. P. Cutchin, a deputy warden of the United States Fish and Wildlife Service in 1939 (letter to Jack

Miner from A. P. Cutchin, Atlanta, Georgia, December 9, 1939).

North Carolina.—In this state, the counties adjoining the reservoirs on the Yadkin (chiefly High Rock, but also Narrows Lake and the Norwood dam impoundment), the Catawba (Oxford reservoir), and the Rocky rivers are the principal wintering grounds of the Southeast population in North Carolina, as band recoveries indicate. According to Pearson *et al.* (1942), the reservoirs of the Yadkin River form the most important of these water areas. They report that William Birsch of the United States Fish and Wildlife Service has estimated that in one year 10,000 geese wintered in that section of the state (year of report not stated).

The Canada goose population using High Rock Lake in recent years has numbered about 600, according to W. P. Baldwin, Jr., of the United States Fish and Wildlife Service. He reports that the flock wintering

along the Great Pee Dee River and at Ansonville has recently totaled about 3,000 (personal communication, March, 1949).

South Carolina.—Pickens (1928) reported the Canada goose to be a common winter resident in upper South Carolina, a statement that is amply supported by the Miner returns of autumn-banded geese. According to Ernest F. Holland, manager of the Carolina Sandhills National Wildlife Refuge (letter to the Jack Miner Bird Sanctuary, December 18, 1946), about 5,000 Canada geese used this refuge and the adjacent Great Pee Dee River basin in the late autumn of 1945. An additional 2,500 were reported using the private waterfowl refuge of Lockhart Gaddy, located near Ansonville, North Carolina. Judged from band recoveries, Lake Murray, an impoundment of the Congaree River, is probably one of the more important bodies of water for Canada geese in South Carolina. Wateree Pond, a much smaller reservoir on the Wateree River, appears to be second in importance. Other rivers used by geese are the Broad, the Saluda (Lake Greenwood), and the Savannah (from Anderson to Aiken counties).

In several years prior to the winter of 1948-49, about 200 Canada geese wintered in the vicinity of McBee in Chesterfield County and about 250 on Lake Murray (W. P. Baldwin, Jr., personal communi-

cation, March, 1949). Another 300 frequented the section of the Savannah River bordering McCormick County. The Santee Cooper Reservoir area harbored about 250 Canada geese, the Cape Romain sector of the Atlantic Coast about 500, and Winyah Bay a small but unknown number. The Winyah Bay flock may be only a segment of the Cape Romain flock that segregates out from time to time. Data on populations at the Santee Cooper and Cape Romain National Wildlife refuges in other recent years are given in table 47.

Alabama.—According to Howell (1924), Canada geese in Alabama are "probably most abundant on the Tennessee River in the vicinity of Muscle Shoals." They are "numerous every winter in the vicinity of Montgomery. On the coast they apparently are not common, though found occasionally." Since 1942, 300 to 900 Canada geese have been reported wintering in the vicinity of the Wheeler Reservoir, according to data in the files of the United States Fish and Wildlife Service.

Sixty per cent of the Miner-banded geese reported killed in Alabama were shot in Tallapoosa, Coosa, and Elmore counties. Over half of the recoveries from these three counties are from the vicinity of Martin Lake, an impoundment of the Tallapoosa River; the remaining returns from these counties are from areas adjoining the Coosa

Table 47.—Numbers of Canada geese wintering at three national wildlife refuges in the Southeast flyway, 1934-1945.

YEAR	REFUGE					
	St. Marks		Cape Romain		Santee Cooper	
	Season	Number	Season	Number	Season	Number
1934-35.....	Winter	5,000	Winter			
1935-36.....	Winter	6,000				
1936-37.....	Winter	9,500				
1937-38.....	Winter	13,500				
1938-39.....	Winter	13,500	Winter	300		
1939-40.....	Winter	6,500	Winter	27		
1940-41.....	Winter	11,500	Winter	50		
1941-42.....	Winter	12,000				
1942-43.....	Winter	11,000	Winter	60	Fall	10
					Spring	20
1943-44.....	Winter	13,000	Winter	83	Fall	120
					Spring	50
1944-45.....	Winter	15,000	Winter	196	Fall	80
					Spring	50

River impoundments (Lay, Mitchell, and Jordan lakes). The flock wintering on Martin Lake numbered about 400 in the winter of 1939-40 (letter to Jack Miner from C. Robinson of Alexander City, Alabama).

Georgia.—Band recoveries from Georgia are spotty, suggesting that no great concentrations of geese occur anywhere in the state, possibly in part because of the comparative lack of large reservoirs or natural lakes. The Savannah River from Hart County to Richmond County appears to be a favored wintering area; the Ocmulgee (Lloyd Shoals Reservoir between Jasper and Butts counties), the Oconee (Washington and Laurens counties), and the Flint River (Pike, Upson, Taylor, and Crawford counties) are other sectors used by Canada geese.

Many of the recoveries from Georgia, however, may be from migrating geese rather than from wintering flocks. As a number of the recoveries are from areas of the state directly north of the St. Marks National Wildlife Refuge on the Florida Gulf Coast, it seems likely that birds en route to St. Marks contribute appreciably to the kills made in Georgia.

In 1941, 150 to 200 Canada geese were reported using Lake Harding, an impoundment created by Bartletts Ferry dam on the Chattahoochee River near West Point (letter to Jack Miner from William B. Fuller, West Point, Georgia, January 10, 1941).

Florida.—The St. Marks National Wildlife Refuge, consisting of 54,681 acres, is believed to contain the greatest single concentration of geese in the Southeast population. Although between 11,000 and 15,000 geese have wintered at this refuge since 1941, table 46, there have been singularly few band recoveries from Miner-banded geese in the surrounding country. This fact suggests that either the bulk of these geese by-pass the Miner Sanctuary on their southward migration, and hence are not banded, or that the kill in the St. Marks area is relatively small. From about 10,000 geese wintering along a 100-mile stretch of coast during the late twenties, the annual kill was said to be several hundred (letter to Jack Miner from R. G.

Porter, Apalachicola, Florida, winter of 1927-28).

Future Status

Although the Canada geese of the Southeast population winter over an enormous area, extending from Virginia to Alabama and the Gulf Coast of Florida, their total number is not large. With the exception of the flock in the St. Marks area, most of the concentrations can be classified as being either small to medium in size and, in the aggregate, may match the St. Marks flock in size. Therein may lie the security of the Southeast population. The small concentrations, by virtue of their size, do not attract other than local hunters, whose kill is probably fairly light. The paucity of band recoveries from the St. Marks area suggests the possibility that the flock there is afforded adequate protection by the St. Marks National Wildlife Refuge.

In any management measures involving the Southeast population, recognition should be given to the fact that the scattered flocks are but segments of a more or less contiguous population on the breeding grounds. These segments should be carefully censused at the time of the annual January inventory and the extent of the kill in each wintering area should also be determined within fairly close limits. To help insure the perpetuation of this population, it may be necessary to declare at least a portion of all reservoirs important to wintering geese, and some adjacent land areas, inviolate to hunting.

Insofar as their habitat requirements in winter are concerned, Canada geese can be considered adaptive birds. They are quick to respond to changing agricultural practices, to the creation of reservoirs, and to the formation of new refuges by changes in their habits and their local distribution. W. P. Baldwin, Jr., reported (personal communication, March, 1949) that increasing numbers of Canada geese are wintering in northern Georgia, where they are resorting to the cultivated fields. At least some of these geese in former years must have migrated down to the St. Marks area. Such "reshuffles" in the population and the problems that arise from them should be recognized in any attempts to manage the Southeast geese.

APPENDIX B

CLASSIFICATION OF THE CANADA GEESE OF THE GENUS *BRANTA*

PROBABLY few other groups of North American birds have presented the taxonomists with greater challenge than the white-cheeked geese of the genus, *Branta*. Before the distribution and the relationships of the various races can be fully understood, much collecting and banding will have to be done on the breeding grounds. The complexity of the problem is apparent when it is realized that the race *Branta canadensis interior* alone can be broken down into four fairly distinct breeding populations. As might be expected, the literature on the genus is fairly voluminous and often contradictory. Some plumage variations once thought to have taxonomic significance have been shown to be merely variations within single populations (Taverner 1931, Elder 1946, Hanson 1949*b*). In the latest revision of the genus by Hellmayr & Conover (1948), the characters of the downy plumage were taken into consideration. This factor considerably enhances the reliability of their study over studies previously made. They list the various members of the genus as follows:

Branta leucopareia leucopareia (Brandt). Tundra goose. [The lesser Canada goose of Kortright (1942) and others.]

Branta leucopareia occidentalis (Baird). West Coast goose. [The Western Canada goose of Kortright (1942) and others.]

Branta minima Ridgway. Cackling goose.

Branta canadensis parvipes (Cassin). Lesser Canada goose. [See Aldrich (1946) regarding the resurrection of *parvipes*.]

Branta canadensis moffitti Aldrich. Great Basin Canada goose.

Branta canadensis interior Todd. Todd's Canada goose.

Branta canadensis canadensis (Linnaeus). Eastern Canada goose.

Branta hutchinsii (Richardson).

Richardson's goose. [*Branta canadensis hutchinsii* of Kortright (1942) and others and sometimes known as Hutchins's goose.]

Taverner (1931) has pointed out that several of the races are markedly distinct in the field, but as skins in the laboratory they are separated only with difficulty. According to James Mark, an Indian living at Eastmain, four different kinds of Canada geese are recognized by the James Bay Indians. The bird called *Muskego nisku* by the Cree Indian, meaning "large swamp goose," is the breeding goose of the muskeg, *Branta canadensis interior*, fig. 82. The "coast goose," *Winnipeg nisku*, is restricted to the James Bay coasts and observed only while on migration. It is reported as being smaller than the swamp goose, more vociferous, and having a relatively shorter neck, a description that fits the lesser Canada goose, *Branta leucopareia leucopareia*. Richardson's goose, *Branta hutchinsii* is called *Apichishkish*, meaning literally a small goose that has attained its full growth, fig. 82. The fourth kind recognized by the Indians on the south and east coasts of James Bay is described as being the largest of the group and possessing a brown breast, a feature from which it has derived its name, *Kaousoupasawat nisku*. Geese of this kind are reported to breed farther north and are called the Fort George (Quebec) geese by the Moose Indians. The brown breast may represent staining by iron-rich waters of the areas frequented by this bird, which may possibly be *B. c. interior*.

It is of interest to note that Blakiston (1863) also reported that an Indian on the Saskatchewan River described four different kinds of "grey geese," the common gray goose, a short-necked goose, a small goose, and a large goose, descriptive names that roughly fit the forms described by the Indians of James Bay.

The chief of the Indians around Lake St. Martin, Manitoba, told Taverner



Fig. 82.—Profile views of (upper head) an interior Canada goose, *Branta canadensis interior* and (lower head) a Richardson's goose, *Branta hutchinsii*. Both specimens are juvenile males.

(Shortt & Waller 1937) that three kinds of Canada geese visit their area. The descriptions of these three varieties fit *canadensis*, *leucopareia*, and *hutchinsii*. According to Taverner's unpublished notes, which Shortt & Waller quote, an immense kind of Canada goose is also traditional with these Indians and "is so rare that it is known only by report. It is probably mythical."

Despite Taverner's disbelief at one time in the reality of a very large goose, Mershon (1925) leaves little doubt that a very large variety of honker existed. McAtee (1944) has also commented on records of large geese from the Plains region. Aldrich (1946) has now recognized this large race of Canada geese, giving it the name *moffitti*. Individuals of this race, presumably adult males, are known to range as high as 14 to 16 pounds, and even greater weights than these have been reported. Elder (1946) weighed 2,179 geese and the senior author weighed several thousand more geese at Horseshoe Lake, Illinois,

without encountering an individual that attained the weight of 12 pounds.

In the light of our present knowledge, the very large, almost legendary Canada goose known to many Indian groups in the boreal forest of Canada might be explained by individuals of the race *Branta canadensis moffitti* that have been occasionally taken north of their normal range. Such occasional invasions of the breeding grounds of one subspecies of Canada geese by nonbreeding members of another adjacent subspecies would not be unexpected. (In the above case the invasion of the range of *B. c. interior* by individuals of *B. c. moffitti* or an even larger extinct variety.) In the summer of 1949, Peter Scott, British ornithologist, and the senior author observed several flocks of nonbreeding "honkers," *B. c. moffitti* or *interior*, in the Perry River (Northwest Territories) breeding grounds of the smaller tundra Canada goose, skins of which have been identified by the senior author as those of *Branta leucopareia leucopareia*.

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Biology of the
White Crappie
in Illinois

DONALD F. HANSEN



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This paper is a contribution from the Section of Aquatic Biology.

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The frontispiece shows fishermen congregated along a riprapped approach to one of the highway bridges across Lake Decatur. (Photograph from Decatur Herald-Review.)



Biology of the White Crappie in Illinois

DONALD F. HANSEN

THE white crappie, *Pomoxis annularis* Rafinesque, and the black crappie, *Pomoxis nigro-maculatus* (Le Sueur), are among the most characteristic and abundant fishes of the lakes and streams of Illinois. They are popular with Illinois anglers and are generally ranked with the better food fishes of the state. Both species have been used extensively for stocking artificial lakes of various sizes.

This paper is based largely on white crappie studies carried on by the writer at Lake Decatur, Macon County, Illinois, during the period beginning in late November, 1935, and ending in early December, 1939. Most of the fish for the Lake Decatur studies were caught in hoop nets that were operated at 1- to 2-month intervals at all seasons of the year.

Year-round collecting at Lake Decatur provided material on the white crappie for determination of spawning time, length of the annual growing period, seasonal fluctuations in plumpness, time of year of high natural mortality, and date of annulus formation. In addition, this collecting brought to light seasonal variations in sex ratios and evidence that the hoop net is less efficient for capture of crappies in warm weather than in cold weather.

Pronounced yearly differences were observed in time of annulus formation (Hansen 1937), length of growing period, size and age distribution, and rate of growth of the white crappie.

Included with information from Lake Decatur is some additional information about crappies that was obtained from

other places in the state as a result of field investigations by various members of the Natural History Survey staff during an 18-year period beginning in 1927.

ACKNOWLEDGMENTS

Most of the crappie information from waters of the state other than Lake Decatur was collected during fisheries investigations carried on by Dr. David H. Thompson while head of the Section of Aquatic Biology of the Natural History Survey. His unpublished observations on length, weight, sex, lymphocystis disease, day and night rates of hoop-net capture, and angling represent important contributions to the paper.

Nearly everyone who worked in the Section of Aquatic Biology of the Natural History Survey in the 18-year period beginning in June, 1927, had a part in the collecting of field data. Francis D. Hunt undoubtedly measured more fish and gathered more scale samples from all parts of the state than any other person. Dr. Louis A. Krumholz helped with all the Lake Decatur collecting from late 1938 through 1939.

During the period of intensive field work at Lake Decatur, Sam A. Parr, then employed by the city of Decatur as lake inspector, and Ely Mooreland, caretaker at Faries Park, furnished information about the lake, helped to provide places to work during bad weather, and sometimes assisted with netting operations.

Photographs of Lake Decatur were lent by the Decatur *Herald-Review*.

The entire manuscript was read by Dr. George W. Bennett, Dr. Elizabeth B. Chase, and James S. Ayars, and parts were read by Agnes C. Hansen and Dr. William C. Starrett. Each offered valuable criticism.

I am especially indebted to Dr. Bennett and Dr. Thompson for what they have contributed through discussion.

METHODS AND TECHNIQUES

Because the white crappies used in this study were taken from a number of different waters, by different collectors, and over a considerable period of time, several methods of collection and techniques of study are represented.

Collections

With the exception of two collections from hook-and-line catches, all of the fish taken from Lake Decatur for this study were trapped in 1-inch-mesh hoop nets, that is, fykes or wing nets, each having a pot or rear compartment of 1-inch mesh (square measure). Most of the fish from other waters also were taken with 1-inch mesh hoop nets, but some fish were taken with hoop nets and seines of other mesh sizes, with hook and line, with rotenone poison, and by draining lakes. The methods of capture are specified throughout the paper in connection with discussion of the data. The 1-inch-mesh hoop nets retain white crappies as small as 4 inches total length. The fish of this length are usually a little over a year old. No effort was made at Lake Decatur to sample fish of lengths less than 4 inches.

Hoop nets of the type used at Decatur and at most other collecting stations are made of netting stretched over a series of wooden hoops to form a cylinder 10 or 12 feet long and usually $3\frac{1}{2}$ to $4\frac{1}{2}$ feet in diameter. Each net is divided into two compartments. A funnel-shaped entrance leads fish into a front compartment; a second funnel leads them into a rear compartment or pot. A "fingerthroat" is used at the inner funnel opening to help prevent reverse movement, that is, prevent escape of fish from the pot. Wings 10 feet long are attached on either side of the hoop at the open end and serve to

guide fish into the trap. Ordinarily a separate lead net, 40 to 60 feet long, is used with each hoop net. Two poles, one at the outer end of each of the wings, and a third, at the end of the pot, are pushed into the lake or stream bottom to hold the net in the "set" position. The lead net is secured in a similar manner. The mesh of the lead, wings, and front compartment of the hoop net is $1\frac{1}{2}$ inches square, while the mesh of the rear compartment, or pot, is 1 inch square. Designations of mesh size of hoop nets mentioned in this paper refer to the mesh of the pot.

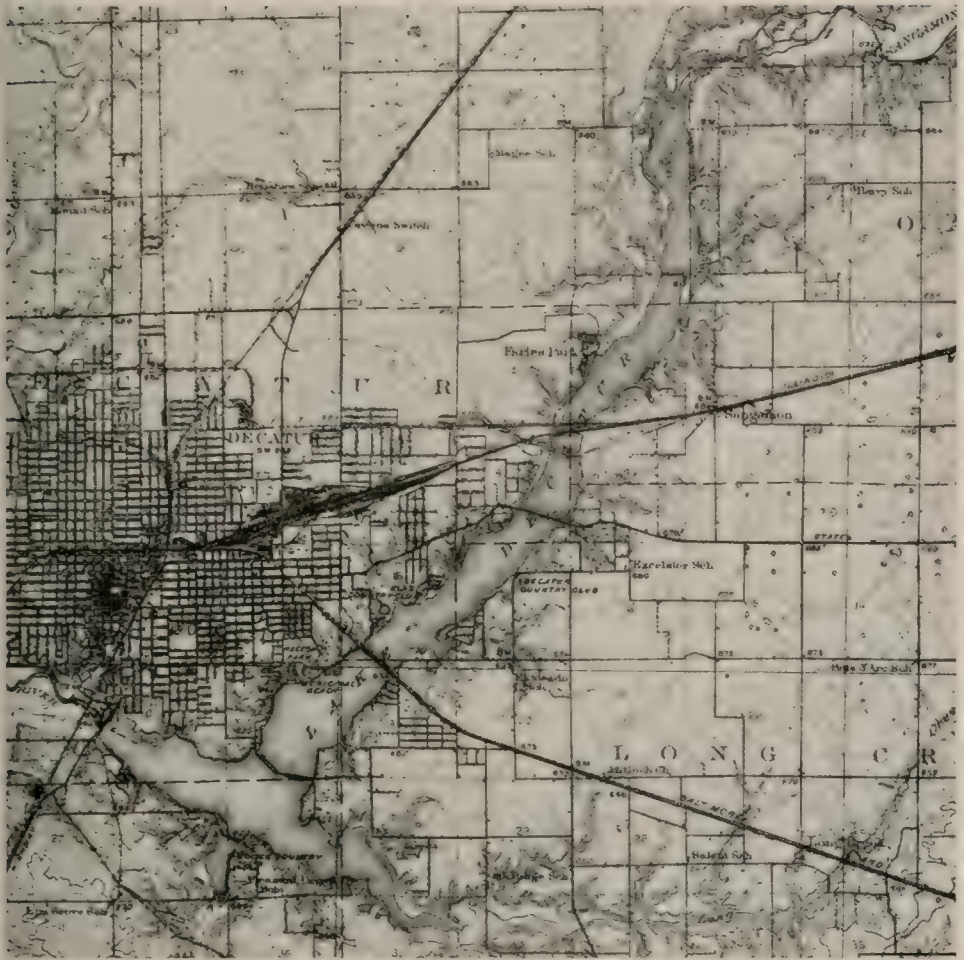
At Lake Decatur and elsewhere, the hoop nets were set usually with a few inches of net standing out of water. For example, a $3\frac{1}{2}$ -foot-diameter net was set where the water was about 3 feet deep. The period between setting the nets and emptying them varied ordinarily from 1 to 3 days.

Two winter hoop-net collections were made at Lake Decatur after the formation of heavy ice over most of the lake. In January, 1938, nets were set in a place that was kept open by warm water from the A. E. Staley plant. This water, which flowed into the lake from a ditch just above Nelson Park, fig. 1, originally was pumped from the lake into a cooling system within the plant, where in the cooling operation it was warmed; it was then returned to the lake. In January, 1939, the nets were set in an open area between the old and new Illinois Terminal Railroad bridges, three-fourths of a mile below Faries Park, fig. 1, on the upper west side of Lake Decatur. Neither at Lake Decatur nor elsewhere were nets operated under the ice.

Length Measurements

Most white crappies included in this study were measured in inches, to the nearest tenth of an inch, on calibrated measuring boards. The 1933 collection of crappies from Senachwine Lake was measured in millimeters.

Standard length was the basis of measurement before January, 1939, and total length after that date. Total length was measured from the tip of the lower jaw to the end of the longest ray of the tail with the mouth of the fish closed and



with the rays of the tail laid parallel rather than fanned. Standard length was measured from the tip of the lower jaw to the crease at the base of the tail. This crease marks the anterior end of caudal rays and is a little forward of the last scales on the tail. The standard-length measurements were converted into total lengths for this paper, except that standard lengths were used in computing coefficients of condition and in discussing length-weight relationships.

following examples from the class intervals:

One-half-inch class interval: 5-inch class (4.8–5.2 inches); 5½-inch class (5.3–5.7 inches).

1-inch class interval: 5-inch class (4.6–5.5 inches); 6-inch class (5.6–6.5 inches).

1½-inch class interval: 6-inch class (5.3–6.7 inches); 7½-inch class (6.8–8.2 inches).

Weight Measurements

Lake Decatur crappies were weighed on a Chatillon dietetic spring balance of 1,000 grams capacity. The dial of the scale was marked at 4-gram intervals, and readings were made to the nearest 4-gram mark.

The fish were iced if necessary to prevent their spoiling when more than a day was required to handle large collections. The 1933 Senachwine Lake crappies 2 inches or more in length were weighed to the nearest one-tenth gram; those less than 2 inches long were weighed to the nearest one-hundredth gram. The crappies from Horseshoe Lake and Craborchard Lake were weighed to the nearest one-hundredth pound. The Senachwine Lake crappies were carefully wiped to remove excess water before being weighed. This practice was not followed elsewhere.

During the first several hours after death it is possible that fish, if kept in water, gain slightly in weight. Repeated weighings of a white crappie that before death had a total length of 8.5 inches and a weight of 148 grams showed after death a weight increase of 2 grams in 4 hours and 6 grams in 7 hours. This fish was kept in ice water between weighings.

There may also be a slight decrease in body length after death which, together with the increase in dead weight over live weight, would tend to give a dead fish a higher coefficient of condition than a live one. Whether this weight change is typical or not, it probably had only a minor effect on the conclusions reached from the length-weight study of the Lake Decatur fish, since measuring and weighing usually were completed within 4 to 5 hours after the fish were removed from the nets.

Identification of Sexes

Differences in breeding coloration were not usually relied upon as a method of distinguishing sex. This method was used for a single collection (June 2-5, 1947) at Lake Decatur, and was also used by Dr. David H. Thompson for his observations on sex in the Illinois River valley in 1942. As shown by tests, however, this method is not entirely reliable, and the rule at Lake Decatur was to dissect a fish when neither eggs nor sperm could be squeezed from the genital opening.

Scale Collections

Thirty to 50 scales were removed from the left side of each fish in the region between the dorsal spines and the lateral

line. At Lake Decatur, to avoid the accidental mixing of scale samples, scaling tools were rinsed after scales had been taken from each fish.

Scale Analyses

Fish ages were determined by counting the number of annual rings on the scales. About half the scale examinations were made with a low-power, binocular, dissecting microscope on uncleaned, unmounted, dry scales. The other examinations were made from the projected images of cleaned scales mounted on slides in glycerine jelly or Farrant's medium.

Interpretation of the growth rings is discussed in the section that deals with age and growth. Age readings were made on practically all white crappie scale material collected in Illinois for the Natural History Survey up to January, 1939, and on some material collected later.

With the following exceptions, age determinations are those of the author: Lynn Hutchens read the scales collected at North Lake, November, 1931, Lake Chauqua, November, 1936, and Weldon Springs Lake, July, 1936; William Hoyer (National Youth Administration) read the scales collected at Senachwine Lake, August-November, 1933. Hutchens read the Lake Decatur scales collected in March-August, 1937; most of the June-August collections of that year were re-examined by the author.

Sampling Procedure

At Lake Decatur, and usually elsewhere, data from hoop nets were obtained from entire catches; no attempt was made to select fish of any particular size. However, about one-third of the scale material from the rest of the state was collected during a Natural History Survey tagging experiment in which only specimens longer than 6 inches were used. Also, some of the fish which the Survey tagged were caught by commercial fishermen, and field notes did not always show whether these fishermen had furnished their entire catches or not. It can be assumed that anglers, from whom some of the data were obtained, did not in all cases keep all of their small fish.

Periods of Study

The over-all period covered by the Lake Decatur collections was late November, 1935, to early December, 1939. Length measurements and scale samples were obtained from all Lake Decatur collections. Weighing was begun in early April, 1936, and continued through 1939. Sex, whether male or female, was recorded at two periods, late May, 1936, through July, 1937, and November, 1938, through December, 1939; records were kept of ripe fish taken at spawning time in 1936, 1937, and 1939.

Age readings and the study of length-weight relationships were terminated with the collection of January 9, 1939. The later 1939 collections were used in the study of size distribution, sex ratio, and seasonal variations in rate of hoop-net capture.

Study Limitations

In certain phases of the Lake Decatur study, analyses were made on the basis of broods. Fish hatched in the same calendar year constituted a brood. Because the brood assignments in collections made in May and June, 1936, at the time of annulus formation were thought to be particularly open to question, the collections taken during those months were not used in making certain analyses.

In general, the study of broods was limited to those from which fish were taken in greatest abundance over the longest periods. The older broods, which disappeared from net catches shortly after the beginning of observations (broods hatched in 1930-1932), were omitted from most analyses.

Some entire collections, or parts of collections, were omitted from consideration when a breakdown of data into several categories resulted in poor representation.

Two collection dates that appear in some of the tables, one in May, 1937, and one in May, 1939, were based on observations of fish caught by anglers. These dates are, therefore, not represented in the tables showing rate of catch in hoop nets.

CRAPPIE DISTRIBUTION

Both the white crappie and the black crappie were reported by Forbes & Rich-

ardson (1920) as occurring in lakes and streams throughout Illinois. The black crappie was reported as the more common species in the glacial lakes of northeastern Illinois, and the white crappie as the more common in the creeks of the state.

Relative abundance of the two species tends to vary sharply in hoop-net sampling, which has provided most of the recent data on distribution of crappies in this state. Although no assurance can be given that net sampling has been adequate in all the localities sampled, it is believed that the relative abundance of the two species has been correctly represented for the various categories of lakes and streams discussed.

In all Illinois water-supply reservoirs that have been intensively studied, white crappies were found to be more abundant than blacks. The whites made up at least 95 per cent, and the blacks 5 per cent or less, of the large number of crappies caught with hoop nets in three reservoirs, Decatur, Craborchard, and Pana; the whites were the only crappies caught in Lake Springfield. The hoop-net observations at Lake Springfield and Lake Decatur were verified by observations of the hook-and-line catch in these reservoirs.

The predominance of white crappies in these reservoirs may be due to one or several factors, three of which are suggested here: (1) a possibly greater suitability of the reservoir habitat for white crappies, (2) a probable predominance of white crappies in feeder streams, (3) a possibly heavier artificial stocking of white crappies.

In most ponds studied by the Natural History Survey, white crappies were found to outnumber blacks. In a poison census of 22 ponds of 12 acres each or smaller (Bennett 1943), both species were found in 14 ponds, only whites were found in 3, and only blacks in 3. In the 14 ponds in which both species were found, whites predominated by weight in 10, blacks in 1; only traces of the two species were found in 3 ponds.

One possible explanation of the predominance of whites in most of the ponds may be the more common occurrence of these fish in "creeks" (Forbes & Richardson 1920), the source of many of the fish used in stocking ponds. The green



Fig. 2.—Public bathing beach at Nelson Park, Lake Decatur, in July, 1943. (Photograph from Decatur *Herald-Review*.)

sunfish, a typical creek species, was found in all but 1 of the 22 ponds censused by Bennett. Another possible explanation may be a predominance of whites in the natural stocking that takes place from feeder streams or from nearby streams that overflow in times of high water. Still another explanation may be a greater suitability of the pond habitat for the whites.

In bottomland lakes bordering the Illinois River, the predominance of one species over the other is not striking. Both species seem to be abundant. Of the crappies taken in a 1942 hoop-net survey of the Illinois River and its bottomland lakes, 56 per cent of the total crappie catch from the lakes were blacks. In collections from most of these lakes, the blacks predominated. In collections from the only two bottomland lakes sampled along the Ohio River, the whites predominated.

In the main channel of the Illinois River, the predominance of the blacks is more pronounced than in the bordering lakes. Of the crappies taken from the main channel in the 1942 survey mentioned above, 73 per cent were blacks. Of the crappies taken in 1944 and 1946 hoop-net surveys of Mississippi River navigation pools (pools 12–26) extending from Dubuque, Iowa, downstream to Winfield,

Missouri, approximately two-thirds were whites.

Data on the following rivers in which both species of crappies occur may not give a true picture of relative abundance, since, in spite of intensive netting operations, rather small numbers of crappies were caught. Records show that more blacks than whites were taken in the Des Plaines River, but that more whites than blacks were caught in the Rock, Kaskaskia (Luce 1933), and Ohio Rivers.

Hubbs & Lagler (1947) stated that the black crappie is less common than the white crappie in silty waters. The relation between siltiness and the predominance of one species over the other is not clearly apparent in the Illinois waters studied. The black crappie, for instance, predominates in some of the silty waters of the Illinois River valley as well as in comparatively non-silty glacial lakes of the northeastern corner of the state.

DESCRIPTION OF LAKE DECATUR

Lake Decatur, fig. 1, is a city water supply reservoir made in 1922 by damming the Sangamon River at Decatur, 75 miles below its source. While the lake was built primarily to meet the home and

industrial water needs of a manufacturing center, recreational uses that include fishing, swimming, and boating are encouraged by the city, figs. 2 and 3.

The lake is 10.4 miles long and varies from one-fourth to three-fourths of a mile

in width; its original area was 2,805 acres. In 1936 Glymph & Jones (1937) found a depth of 15 feet at the dam and a depth of 6 feet midway in the lake between upper and lower ends.

Oxygen analyses made on July 29,



Fig. 3.—Sail boating on Lake Decatur; the *Aloha* in 1939. (Photograph from Decatur *Herald-Review*.)

1932, by D. J. O'Donnell, then of the Natural History Survey, indicated a fairly uniform distribution of dissolved oxygen from surface to bottom.

Ice covers most of the lake for about 2 or 2½ months of the year. Some dates of

1936–1946. In *The Story of a Lake*, Walker (1949) has given a popular account of the silting of Lake Decatur.

The turbid condition of Lake Decatur probably accounted for the scarcity of aquatic plants at the time of this study.

Table 1.—Species and numbers of fish caught in 1-inch mesh hoop nets at Lake Decatur during the period April, 1936, through September, 1937.

SPECIES*	NUMBER OF FISH CAUGHT
Shortnose gar, <i>Lepisosteus platostomus</i> Rafinesque.....	6
Gizzard shad, <i>Dorosoma cepedianum</i> (Le Sueur).....	614
Buffalofishes, <i>Megastomatobus cyprinella</i> (Valenciennes), <i>Ictiobus niger</i> (Rafinesque), and <i>I. bubalus</i> (Rafinesque).....	268
Carp sucker, <i>Carpiodes</i> sp.....	292
Spotted sucker, <i>Minytrema melanops</i> (Rafinesque).....	1
White sucker, <i>Catostomus commersonnii</i> (Lacépède).....	3
Redhorse, <i>Moxostoma</i> sp.....	119
Carp, <i>Cyprinus carpio</i> Linnaeus.....	141
Golden shiner, <i>Notemigonus crysoleucas</i> (Mitchill).....	3
Channel catfish, <i>Ictalurus lacustris</i> (Walbaum).....	150
Yellow bullhead, <i>Ameiurus natalis</i> (Le Sueur).....	1
Black bullhead, <i>Ameiurus melas</i> (Rafinesque).....	160
Flathead catfish, <i>Pilodictis olivaris</i> (Rafinesque).....	4
Pike, <i>Esox lucius</i> Linnaeus.....	2
White crappie, <i>Pomoxis annularis</i> Rafinesque.....	2,531
Black crappie, <i>Pomoxis nigro-maculatus</i> (Le Sueur).....	123
Warmouth, <i>Chaenobryttus coronarius</i> (Bartram).....	1
Green sunfish, <i>Lepomis cyanellus</i> Rafinesque.....	3
Bluegill, <i>Lepomis macrochirus</i> Rafinesque.....	97
Pumpkinseed, <i>Lepomis gibbosus</i> (Linnaeus).....	8
Largemouth black bass, <i>Micropterus salmoides</i> (Lacépède).....	29
Yellow perch, <i>Perca flavescens</i> (Mitchill).....	22
Yellow bass, <i>Morone interrupta</i> Gill.....	880
Freshwater drum, <i>Aplodinotus grunniens</i> Rafinesque.....	391

* Common and scientific names from American Fisheries Society Special Publication No. 1 (Anonymous 1948).

ice departure were February 23, 1936, February 28, 1939, and March 13, 1940.

Glymph & Jones (1937) showed that during the first 14 years of impoundment, 1922–1936, sediment had been laid down on the bottom to a depth that averaged 1 foot near the dam and increased gradually to 2 feet in the upper portion of the lake. Deposits of sediment from 3 to 7 feet thick were measured in the old river channel in the main part of the lake. The river channel above the lake had remained quite clear of deposits as a result of the scouring action of floods. The accumulation of sediment in Lake Decatur had resulted in a loss of 14 per cent of the original storage capacity of the reservoir, or 1 per cent per year. According to Brown, Stall, & De Turk (1947), the rate of loss increased to 1.2 per cent per year during the period

While in some places there were extensive beds of water primrose (*Jussiaea* sp.), arrowhead (*Sagittaria* sp.), and cattail (*Typha* sp.), most of the shore line was bare of emergent aquatic plants. No plants of strictly underwater habit were recorded, although they may have been present in some areas.

The bottom fauna of this lake was studied by Gersbacher (1937) and the plankton by Eddy (1932).

A list of the species of fish and numbers of each kind caught in Lake Decatur with hoop nets from April, 1936, through September, 1937, is shown in table 1. The species composition of anglers' catches at Lake Decatur as observed in partial censuses is shown in two tables: table 2, representing counts by the writer of the catches of 71 fishermen who were using

Table 2.—Species and numbers of fish caught with live minnows by 71 bank fishermen at Lake Decatur, as shown by stringer counts in May, 1937, and May, 1939.

SPECIES	NUMBER OF FISH CAUGHT MAY 16, 1937, BY 13 FISHERMEN	NUMBER OF FISH CAUGHT MAY 17-20, 1939, BY 58 FISHERMEN
Channel catfish.	—	5
Flathead catfish.	1	1
White crappie...	86	102
Black crappie...	1	—
Green sunfish...	2	—
Sunfish*.....	—	1
Largemouth bass	1	—
Yellow bass. . .	1	—
Freshwater drum.....	4	3
Total.....	96	112

* Kind not specified.

Table 3.—Kinds and numbers of fish caught with earthworms by Harold Taylor in year-round fishing at Lake Decatur; 179 trips during the years 1934-1938.

KIND OF FISH*	NUMBER OF FISH CAUGHT
Buffalo.....	3
Silver carp.....	1
Sucker and redborse.....	9
Carp.....	169
Channel cat.....	113
Bullhead.....	1,089
Flathead cat.....	2
Crappie.....	11
Sunfish.....	160
Yellow bass.....	245
Sheepshead.....	690
Total.....	2,492
Total weight, 1,012 pounds	

* Names of fish are those used by Harold Taylor in his records. The sheepshead is the same fish as the freshwater drum.

live minnows for bait, and table 3, showing the catch of one fisherman, Harold Taylor, in the course of 179 trips (mostly at the head of the lake), in year-round fishing over a 5-year period. While Taylor's personal record shows that a variety of species could be caught in the lake, there was relatively little fishing for any kind but crappies. Many Decatur residents and many people from surrounding towns took

advantage of the crappie fishing. Stringers examined at Lake Decatur in 1937 and 1939, table 2, as well as those examined in 1935, contained many more white crappies than black crappies.

SPORT FISHING

At Lake Decatur, fishermen interviewed during the period of field work reported that they caught white crappies principally from March 1 to June 1 and that midsummer fishing was a waste of time for most of them. In 1935, however, crappies continued to bite well until mid-July. In some Illinois localities crappie fishing is less confined to the spring months than at Lake Decatur and in a few is continued during most of the year.

At Lake Chautauqua, the most productive crappie fishing in 1941 and 1942 came in May and June (Hansen 1942), while the best fishing in 1944 came between mid-July and mid-September. A 12-year fishing record for Rinaker Lake, Macoupin County, studied by Dr. David H. Thompson (unpublished) showed that June, July, and October were the best months for crappie fishing at that lake, with July somewhat better than the other 2 months. Illinois crappies sometimes bite well in midwinter as shown by excellent catches made in January of some years in open water areas at the edge of Lake Chautauqua. The numbers and kinds of crappies caught have not been recorded and may have included both species.

At Lake Decatur, during the period of this study, crappie fishermen generally fished on the approaches to the several railroad and highway bridges that cross the lake. Here most of them sat on the broken concrete riprap and fished with cane poles and live minnows, frontispiece. At this lake, fishermen did little crappie fishing from the natural lake shore or from boats.

In most other parts of Illinois, as at Lake Decatur, still fishing with live minnows is doubtless more common than casting, trolling, or fly fishing. At Rinaker Lake, however, the preferred method is trolling with either live or dead minnows. According to Evermann & Clark (1920), trolling was at one time a favorite method of taking crappies at Cedar Lake, Indiana.

Large crappies are occasionally caught on bass plugs. Worms and artificial fly-rod baits are effective at times. Larry Simand, who, while living at Canton, often fished for crappies with artificial baits at Lake Chautauqua, recommended the following fly-rod baits: Paulson's Pilk (weedless) with pork rind, Pflueger Pilot flies, Pflueger Pippin Wobbler, and four patterns in trout flies—white miller, red ibis, royal coachman, brown hackle.

Robert Page Lincoln, outdoor writer, is credited with describing a trolling lure that he considered as good a crappie bait as a live minnow. This bait consisted of a strip of freshly caught fish measuring a little over an inch in length (with skin on one side) placed on a hook below a one-half to three-quarter inch gold-plated spinner; a 4-foot gut leader was used between the spinner shaft and line.

A few fishermen employed special methods and were successful in catching crappies at Lake Decatur throughout the summer. The method described by E. F. Zehnpfund involved wading near the bank where the water was 1 or 2 feet deep and slowly bobbing a minnow up and down near projecting sticks and brush. This fisherman emphasized that where obvious cover, such as brush, was scarce he did not overlook the most isolated projecting weed stalk as a possible place to catch a fish.

Robert Witke used a different method for catching crappies in the summer: A stake was driven into the lake bottom with 2 or 3 feet left projecting above the water. A line with hook attached was fastened to the top of the stake so that a live minnow placed on the hook was able to swim only in a small area close to the surface. The crappies then came to the surface to take the bait.

Mr. and Mrs. O. D. Zook of Springfield have fished for white crappies in Lake Springfield for many years and have established for themselves a local reputation as expert crappie fishermen. While most fishermen at Lake Springfield, like those at Lake Decatur, have difficulty in catching crappies in midsummer. Mr. and Mrs. Zook have usually been able to catch these fish from early spring to late fall by varying their fishing methods with season of the year. They use artificial lures as well as minnows. Mr. Zook, who special-

izes in artificial fly-rod baits, has had success with a small spinner and white fly combination and with various all-metal baits (Pflueger Pippin Wobbler, Arbogast Tin Liz, South Bend Trix Oreno) and with homemade baits patterned after the baits named. He is of the opinion that these metal baits are improved by replacing their metal "flippers" with a strip of thin white rubber, one-eighth inch wide by 1 inch long, tapered to a point. He has used artificial lures mainly in his spring and fall fishing.

The Zooks fish with minnows in shallow water in the spring but in deep water in the summer; in early spring from a bank where the water is only 1 or 2 feet deep, and later, in May and June, from a boat dock where the water is 6 to 8 feet deep. When the weather becomes hot and they can no longer catch crappies from the boat dock, they fish with minnows from a boat in a submerged creek channel at a depth of 10 to 15 feet. These two fishermen believe that locating concentrations of fish is one aspect of successful crappie fishing and making the crappies bite is another. Mrs. Zook has written as follows:

"Sometimes a foot in depth or a foot to one side or the other makes a difference of an empty or full stringer. I bob the minnow up and down—move it sideways through the water—change spots if it is only a few inches. I keep the minnow moving constantly. If the crappies don't hit almost as soon as the minnow is dropped in, you may as well move around and aggravate them until they do hit. I know it is possible to do that. In the spring I saw a 14-inch crappie in the boat house; it took me 25 minutes to catch him. If ever a crappie was aggravated, he was. I dangled a minnow all over him—it was interesting how he would knock the minnow out of his way."

The Zooks believe that crappies like to stay in and around brush and snags, and that these fish sometimes show a preference for small minnows over large minnows. Two Peoria Lake fishermen were sure that large-size crappies, kind not mentioned, preferred small minnows while medium-size crappies were not so particular about the size of the minnows.

In Lake Springfield, where most of the crappies are small, the Zooks usually made

their best catches of large crappies during the first 3 weeks in May and continued to make good catches of small crappies for several weeks longer.

Many fishermen keep quite small crappies when large ones are scarce. Of 32 stringers containing white crappies examined at Lake Springfield, May 22-25, 1941, 30 stringers contained white crappies that measured 7 inches or less, total length. A grouping of the 296 white crap-

pies found on the 32 stringers into half-inch length classes showed that 66 per cent fell in the 5½- to 7-inch classes, 27 per cent in the 7½- and 8-inch classes, and 7 per cent in the 8½-inch class or above.

NET SAMPLING

In hoop-net fishing for crappies, variations have been found in the rates of capture at different seasons; also, in the

Table 4.—Seasonal variation in rate of capture of white crappies in 1-inch-mesh hoop nets in Lake Decatur.

DATE OF COLLECTION	SAMPLING STATION	NUMBER OF NETS	NET- DAYS	NUMBER OF WHITE CRAPPIES CAUGHT	NUMBER PER NET- DAY
1935					
Nov. 22.....	Faries Park.....	2-3	3	78	26
1936					
April 3.....	Faries Park.....	3	16	326	21
May 4-6.....	Faries Park.....	1	4	75	19
May 29-June 4	Faries Park and Big Creek.....	1	7	100	14
June 22.....	Faries Park.....	1	3	15	5
July 3-5.....	Big Creek.....	1	6	48	8
July 31-Aug. 3	Big Creek.....	1	5	73	15
Sept. 8-14.....	Big Creek.....	1	6	29	5
Sept. 22.....	Nelson Park Beach.....	2	4	61	15
Oct. 24-27.....	Faries Park.....	3	12	240	20
Dec. 21.....	Staley's Outlet.....	3	15	297	20
1937					
March 1-4.....	Faries Park.....	2	16	666	41
April 24.....	Faries Park.....	2	6	117	20
June 3-5.....	Faries Park.....	3	12	233	19
June 24.....	Faries Park.....	3	9	140	16
July 10-16.....	Faries Park.....	3	27	94	3
Aug. 6-14.....	Big Creek, Lost Bridge, and Beverly Heights.....	3	30	74	2
Sept. 22.....	Faries Park.....	3	6	218	37
Nov. 3.....	Faries Park.....	3	6	170	28
1938					
Jan. 17-24.....	Staley's outlet.....	3	17	18	1
March 14.....	Faries Park.....	3	9	266	30
May 28.....	Faries Park.....	4	8	108	14
July 1-14.....	Faries Park.....	3	9	42	4
Aug. 25.....	Faries Park.....	7	14	79	6
Oct. 6.....	Faries Park.....	4	10	67	7
Nov. 4-11.....	Faries Park.....	3-4	20	75	4
1939					
Jan. 9.....	¾ mile below Faries Park.....	4	12	159	13
March 24.....	Faries Park.....	4	16	315	20
May 3.....	Faries Park.....	4	8	148	19
May 29.....	Faries Park.....	4	12	122	10
June 20.....	(Not recorded).....	6	12	136	11
July 13-17.....	Faries Park and ½ mile below.....	4	15	302	20
Aug. 24.....	Faries Park.....	4	12	82	7
Oct. 16.....	Nelson Park Beach.....	3	6	270	45
Dec. 11.....	Nelson Park Beach.....	6	24	829	35

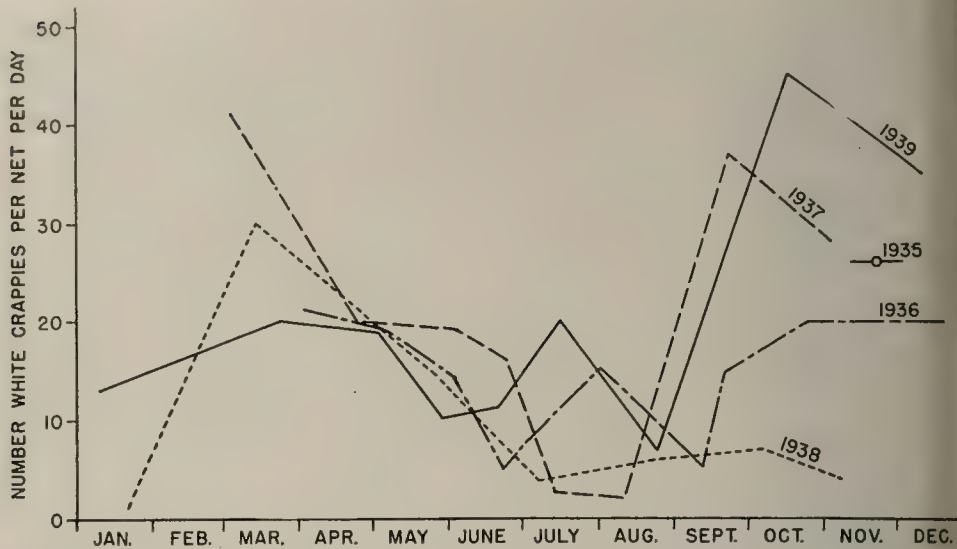


Fig. 4.—Seasonal variation in the rate of capture of Lake Decatur white crappies in inch-mesh hoop nets in the years 1935–1939.

rates of capture of the two species at different times of day and from week to week.

Seasonal Variations

Ordinarily the Lake Decatur crappies were more readily trapped in fall, winter, and spring than in summer. They were least readily trapped from about mid-July to late September, table 4 and fig. 4. The more noticeable departures from this trend include comparatively good catches in July, 1936, and July, 1939, and comparatively poor catches in January, October, and November, 1938. To some extent the wide fluctuations in catch rate at Lake Decatur may have resulted from lack of uniformity in sampling procedure. Thus, number of nets in use, number of days of operation, manner of setting, and occasional shifting of the nets from the Faries Park area to other places on the lake were all variables that might have affected the catch. All of the sampling in 1937 and 1938 was done in the Faries Park area, with the exception of the August collection in 1937 and the January collection in 1938. Summer mortality of crappies, discussed in the section "Size and Age Distribution," may have contributed to the poor summer net fishing at Lake Decatur.

Hoop-net sampling at Lake Glendale, Pope County (unpublished data), has shown similar seasonal trends in catchability of the bluegill, *Lepomis macrochirus*, and the largemouth bass, *Micropterus salmoides*. Lake Glendale netting operations were carried on at specified stations, and sets were duplicated the year round.

According to statements of commercial fishermen on the Illinois River, carp and buffalo also are trapped with difficulty in the summer months.

Species Variations

Differences in behavior patterns of black crappies and white crappies are suggested by differences in rates of capture of the two species.

Catch Rates at Night and During Day.—A hoop-netting experiment (results unpublished) carried on by Dr. David H. Thompson in 1931 at Meredosia Bay, one of the large bottomland lakes along the Illinois River, suggests the presence of a daily rhythm in crappie movement. The hoop nets were raised, emptied, and reset twice daily at the approximate hours of 6 A.M. and 5 P.M. on 25 different days during the period of June 24 through August 17. Nets were set within about 150 feet of the

Table 5.—Catches of white crappies and black crappies in morning and evening raises of 1-inch-mesh hoop nets. Data from an unpublished study made by David H. Thompson at Meredosia Bay, near Meredosia, Illinois, summer of 1931.*

DATE	NUMBER OF NETS	NUMBER OF WHITE CRAPPIES		NUMBER OF BLACK CRAPPIES	
		6 A.M. Raise	5 P.M. Raise	6 A.M. Raise	5 P.M. Raise
June 24	10	373	196	527	183
June 30	6	127	46	169	25
July 1	6	138	51	247	27
July 7	6	136	90	103	14
8	6	79	63	74	14
9	6	84	64	31	28
10	6	44	84	10	3
July 14	4	132	58	256	64
15	4	182	45	418	16
16	4	162	42	332	11
17	4	221	50	364	21
July 21	4	130	40	821	51
22	4	259	98	1,311	158
23	4	120	69	529	56
24	4	316	56	1,002	63
July 28	4	45	17	83	19
29	4	25	6	73	14
July 31	6	140	35	297	41
Aug. 4	4	49	9	32	4
Aug. 11	4	38	65	11	30
12	4	57	46	37	9
13	4	68	77	63	15
14	4	64	46	32	10
17	6	74	23	64	3
Total	—	3,063	1,376	6,886	879

* Horizontal broken lines set off raises made in the same locations. Fishing was carried on in nine different parts of the lake during this experiment.

Table 6.—Rates of capture of white crappies and black crappies in short periods of fishing with 1-inch-mesh hoop nets. Data from an unpublished study made by David H. Thompson at Meredosia Bay, near Meredosia, Illinois, summer of 1931.

NET STATION	PERIOD OF FISHING	TOTAL NET-DAYS	NUMBER OF FISH		CATCH PER NET-DAY	
			White Crappies	Black Crappies	White Crappies	Black Crappies
A	June 24	10	569	710	60	71
B	June 30-July 1	12	362	468	30	39
C	July 7-10	24	644	277	27	12
D	July 14-17	16	892	1,482	56	93
E	July 21-24	16	1,088	3,991	68	249
F	July 28-29	8	93	189	12	24
G	July 31	6	175	338	29	56
H	Aug. 4	4	58	36	15	9
I	Aug. 11-17	22	1,134	274	52	12

shore where the water was about the depth of the nets or shallower. The location of the nets was changed at weekly intervals.

The experiment showed that except on a few dates both species entered the nets in larger numbers between the hours of 5 P.M. and 6 A.M. than in the remaining hours of the day, table 5. During the whole experiment the raises at 6 A.M. yielded approximately twice as many whites and eight times as many blacks as the raises at 5 P.M. It is not known whether fish in the 6 A.M. raises had entered the nets during the hours of total darkness. It is presumed, however, that many had.

The following are offered as explanations of the larger catches at night: (1) The fish possibly were more vulnerable to capture during the hours of darkness when less able to avoid the nets or see their way of escape if once captured. (2) They possibly were more concentrated near shore during all or part of the night period (this explanation implying in-shore and off-shore movement, perhaps for purposes of feeding). (3) They possibly were more actively engaged in swimming at night than during the day. It is not believed that the longer night period, 13 hours as compared with 11 hours during the day, could fully account for the differences observed:

A striking difference between white crappies and black crappies in the degree of expression of this day-night catchability was found. Morning raises yielded more blacks than whites, evening raises more whites than blacks, table 5.

Catch Rates by Weekly Periods.—

Additional evidence that white crappies have different behavior patterns from those of black crappies is shown by comparing catch totals by 1-week periods. In tables 6 and 7, catch totals of white crappies and of black crappies are shown for hoop-net fishing carried on at Meredosia Bay in 1931 and at Lake Chautauqua at various times in the period 1931-1945. These tables show that in both lakes the ratios of numbers of these two species often fluctuated widely from week to week, sometimes in spite of large catches of both species. It must be emphasized, however, that the netting sites were changed at frequent intervals at both Meredosia Bay and Lake Chautauqua and

Table 7.—Fluctuations in numbers of white crappies and black crappies collected during short periods of fishing with 1-inch-mesh hoop nets at Lake Chautauqua, near Havana, Illinois, 1931-1945.

DATE OF COLLECTION*	NUMBER OF WHITE CRAPPIES	NUMBER OF BLACK CRAPPIES
<i>1931</i>		
June 11-13.....	48	205
<i>1934</i>		
April 4-May 4.....	6	1,303
<i>1935</i>		
Nov. 14-25.....	5	34
<i>1936</i>		
Feb. 12-April 12.....	3	18
Sept. 1-6.....	134	45
Sept. 7-13.....	455	241
Sept. 14-20.....	117	119
Sept. 21-27.....	158	141
Sept. 28-Oct. 4.....	465	179
Oct. 5-11.....	160	305
Oct. 12-18.....	208	465
Oct. 26-Nov. 1.....	24	145
<i>1937</i>		
March 29-April 5.....	113	665
April 26-30.....	74	134
May 4-5.....	17	21
<i>1940</i>		
March 21-27.....	1,803	673
March 29-April 4.....	3,281	2,150
April 5-11.....	516	935
April 12-18.....	1,444	412
April 19-25.....	992	846
April 26-May 2.....	281	307
May 10-16.....	618	373
May 17-23.....	2,772	1,267
May 24-30.....	279	196
<i>1941</i>		
April 7-14.....	1,177	1,068
May 29-June 4.....	24	264
Nov. 9-10.....	57	160
<i>1942</i>		
May 4-14.....	586	597
July 10-11.....	20	253
<i>1943</i>		
April 27-29.....	128	50
May 27-June 2.....	266	128
Sept. 17-18.....	230	3
<i>1945</i>		
April 21-23.....	356	119
<i>Total.....</i>	<i>16,817</i>	<i>13,821</i>

* The number of net-days per period was not uniform throughout the study because of variation in length of periods and in number of nets used.

that differences in catch ratios may have been due to differences in concentrations of the two kinds of fish at the various netting stations. It might be speculated further that the whites and blacks school by individual species and that the number of each species caught during any 1-week period was determined principally by chance, that is, by the number of schools encountering the nets. Another possible explanation for the unstable catch ratios is that, as a result of environmental changes, for example, changes due to weather, the two species behaved differently and reacted differently to hoop nets.

FOODS

The published observations of Forbes & Richardson (1920), Pearse (1919), Ricker & Lagler (1942), Eddy & Surber (1947), and Johnson (1945) show that the principal foods of both white crappies and black crappies are small fish, aquatic insects, and small crustaceans. The relative importance of the three types of food mentioned have differed considerably in the crappie collections studied by different men, possibly in consequence of local differences in food supplies or in the time of year collections were made.

Only limited observations were made on the feeding habits of white crappies in

Table 8.—Percentages of foods (by volume) found in the stomachs of 64 white crappies and 190 black crappies from the Rock River system, 1924–1927. Data from an unpublished study by R. E. Richardson.

KIND OF FOOD	PERCENTAGE OF FOOD BY VOLUME	
	White Crappie	Black Crappie
Terrestrial insects.....	0.60	0.71
Aquatic insects.....	34.96	45.65
Other aquatic invertebrates.....	1.17	0.47
Fishes.....	57.88	44.07
Animal matter unclassified.....	5.06	8.72
Vegetable matter.....	0.12	0.04
Organic matter mixed....	—	0.16
Earth and mineral matter.	0.21	0.18
Total.....	100.00	100.00

Lake Decatur. In the summer of 1936, the winter of 1936–37, and the spring of 1937 the stomachs of the white crappies from this lake were often found to be filled with small gizzard shad, *Dorosoma cepedianum*, which were abundant at that time. Some findings of a previously unpublished study of the food of Rock River crappies made for the Natural History Survey by the late R. E. Richardson are shown in table 8.

MIGRATIONS

By means of tagging operations carried on in a number of the large rivers and adjoining lakes in various parts of Illinois, Thompson (1933) found that both white crappies and black crappies are given to travel. He observed upstream and downstream movements, and concluded that the movements of the crappies, as well as the other species tagged, are random or haphazard. Four white crappies were recaptured upstream, 3.5, 8, 16, and 18 miles from tagging points; three others were retaken downstream, 1, 2, and 3 miles from tagging points. The distances of travel were similar for the black crappies except that one black crappie was caught 77 miles upstream.

There is little if any indication from Thompson's study that these movements of crappies were related to spawning.

Eschmeyer (1942) found that six tagged crappies (kind not specified) in Norris Reservoir were retaken at distances of 0 to 18 miles from points of tagging.

Miller & Bryan (1947) reported recapture of nine tagged white crappies at distances of 0.1 to 1.2 miles from the point of tagging in Wheeler Reservoir, 6 to 41 days after the date of tagging.

REACTION TO CURRENT

At Lake Springfield, Sangamon County, in May, 1941, white crappies were observed concentrated in front of an 8-by-10-foot wire screen fastened to a culvert that delivered a large volume of water into the lake from an electric power plant. The water coming from the culvert entered the lake at the lake level, that is, there was no fall. The crappies could be caught

readily with a dip net. In 11 dips with a circular net measuring 2 feet across, 60 white crappies were taken. These measured 5 to 9 inches in length, averaging about 6 inches. Positive reaction to strong currents is, of course, well known for a number of species of fishes. No temperature readings were obtained at the culvert outlet.

REPRODUCTION

Biologists regard a knowledge of the facts of fish reproduction as of special importance in their efforts to bring about population increases in certain species of fish. Both kinds of crappies in Illinois waters show a strong tendency to reproduce in adequate numbers, so that artificial aids to reproduction have so far not seemed necessary. It is possible that a knowledge of the facts of crappie breeding may prove to be of use in the development of methods of limiting already overcrowded populations.

Sexual Maturity

Sexual maturity in Illinois white crappies is reached at the end of the second or third year, that is, at an age of about 24 or 36 months. There is no indication that white crappies in Illinois ever spawn when 1 year old, although spawning at 1 year has been observed in Texas black crappies (Harper 1938). Only about a third of the white crappies hatched at Lake Chautauqua in the spring of 1938 appeared to be approaching maturity as 2-year-olds (ages determined by scales and by size distribution) when specimens were examined in May, 1940. In a sample of 127 2-year-old females examined on May 16, dissections showed that the ovaries of only 40 contained well-developed (large) eggs. The ovaries of the other 87 females of that age group were still in an immature stage and it was believed that none of this group of 87 2-year-olds would reach maturity during the 1940 spawning season. The 40 mature females averaged 6.2 inches total length, while females in which the eggs were undeveloped averaged 5.8 inches.

Fully mature, 2-year-old white crappies (ages determined by scales) were captured at Lake Decatur on June 3-5, 1937; in-

cluded were ripe individuals of both sexes. These fish averaged approximately 2 inches longer than the ones from Lake Chautauqua that did not seem to be maturing as 2-year-olds.

Among 2-year-old white crappies examined by Eschmeyer, Stroud, & Jones (1944) from one of the reservoirs of the Tennessee River, some were mature and others were not.

The smallest ripe white crappie observed in Illinois was a female of 5.6 inches, total length, caught on May 20, 1941, at Lake Springfield. The scales of this fish did not show clearly whether its age was 2 or 3 years.

Breeding Coloration

The coloring of male and female white crappies is identical except during and near the spawning season, when the breeding males typically turn darker, while the females typically remain unchanged in color. The darker coloring of the male, darker in some individuals than in others, is most noticeable on the sides of the head, chin, and breast, and to a lesser extent on the sides of the body. It begins to appear in April, reaches maximum intensity about the last of May, and is lost in most males by the last of June. The disappearance of the breeding color seems to take place gradually, and some males retain remnants of the breeding pigmentation well into July.

The following tests were made to discover the degree of error in using breeding color as a basis for sex recognition in spring collections of white crappies. The fish were first sorted as to sex on the basis of color; then they were opened and their reproductive organs were examined. In these tests, it was found that sex was usually guessed correctly, but that errors were sometimes made in fish large enough to be sexually mature as well as in small fish which may have been immature.

At Lake Decatur, 100 specimens were examined in the period May 17-20, 1939. Among 19 white crappies first judged to be males by their dark pigmentation, dissection showed 18 males and 1 very darkly pigmented female. Among 81 judged to be females by the absence of dark pigmentation, dissection showed 2

males and 79 females. The true ratio was 20 males and 80 females, instead of 19 males and 81 females.

At Lake De Pue on April 26, 1942, 3 males and 12 females were correctly sexed by means of breeding color.

At Lake Springfield on May 20, 1941, a group of 36 white crappies classified as females on the basis of color included 7 light-colored males. Fish showing male pigmentation were not dissected.

Light-colored males in the tests were of the following total lengths: at Lake Springfield, 6.3, 6.3, 6.5, 6.6, 7.2, 7.2, and 8.4 inches; at Lake Decatur, 8.1 and 8.7 inches; and, at Lake Chautauqua, 8.7 and 9.8 inches. Some of the males, though possibly not all of them, were large enough to be sexually mature. The one female caught at Lake Decatur that was so dark it was mistaken for a breeding male was 10.2 inches long.

Spawning Season

After examining market specimens at Havana, Illinois, Forbes & Richardson (1920) gave May as the spawning time of the white crappie in this state. White crappies were observed on nests at Lake Springfield on May 26, 1941 (Hansen 1943). The black crappie evidently nests about the same time as the white. Forbes & Richardson reported that the black crappie spawned in May at Havana in 1898. Richardson (1913) found a nesting black crappie at Havana on May 2, 1911.

Frank Rhodes of Carlinville, Illinois, stated on the basis of several years of observation that crappies (kind not specified) nest at nearby Beaverdam Lake in May and again in September. September nesting has not been reported elsewhere and it is possible that the behavior of nesting was observed in September when nesting was not actually taking place.

Eddy & Surber (1943) reported that in Minnesota the white crappie spawns in late spring and early summer, and that the black crappie usually spawns in May and June but that spawning has been observed in July. Pearse (1919) found nesting black crappies at Madison, Wisconsin, on May 20, 1916.

Eschmeyer & Smith (1943) found that spawning of crappies might be delayed or

prevented if the fish were kept at continuously low water temperatures.

The approximate spawning date of the white crappie in Illinois is further indicated by occurrence of ripe and unripe gonads, table 9. A ripe condition of the gonad was detected by squeezing, with moderate pressure, on the sides of the fish in the region just above the vent. Males were classified as ripe if they yielded milt, and females if they yielded runny, sticky, translucent eggs. An individual of either sex was not considered ripe if hard squeezing was required to obtain eggs or milt.

Squeezing tests indicate that May and June are perhaps equally important months for white crappie spawning in Illinois, and that the height of the spawning season usually falls in late May or early June. Field records noting the occasional finding of a ripe male or female show that some spawning may occur in July. Ripe male white crappies have been found as early as May 16 and as late as June 24, while ripe female white crappies have been found as early as May 6 and as late as July 13.

Changes in Ovary Size

Enlargement of the ovaries of white crappies has been observed in Illinois from early April through June or early July. This enlargement results from enlargement of the eggs. Squeezing tests indicate that some eggs ripen in advance of others and occasional dissections show that eventually the ovary contains practically a solid mass of ripe eggs. Close attention has not been paid to the time of year when the ovary starts to enlarge in preparation for a new spawning season. However, the occurrence of the reduced or post-spawning stage has been noted as follows at Lake Decatur: July 3-5, 1936, 16 females had reduced ovaries while 9 females still had more or less enlarged ovaries; July 31-August 3, 1936, all of the 39 females examined had reduced or immature ovaries, table 9. Presumably the July 31-August 3 collection included some mature females which had completed the spawning cycle.

Even though collecting was not continuous throughout the spawning period, the fact that the writer failed to observe a

Table 9.—Counts of sexually ripe¹ male and female white crappies in central Illinois.² All fish caught in 1-inch-mesh hoop nets, except as shown.

DATE OF COLLECTION	PLACE	MALES			FEMALES		
		Num- ber Exam- ined	Num- ber Ripe	Per Cent Ripe	Num- ber Exam- ined	Num- ber Ripe	Per Cent Ripe
May 28, 1936 ³	Sangamon River, Decatur	5	1	20	4	1	25
May 29–June 4, 1936 . . .	Lake Decatur . . .	39	1	3	63	21	33
July 3–5, 1936	Lake Decatur . . .	17	0	0	28 ⁴	0	0
July 31–Aug. 3, 1936 . . .	Lake Decatur . . .	43	0	0	39 ⁵	0	0
June 4, 1937	Lake Decatur . . .	79	45	57	123	54	44
June 24, 1937 ⁶	Lake Decatur . . .	—	—	—	81	—	5–10
May 28, 1938	Lake Decatur . . .	—	—	—	15	1	7
May 17–20, 1939 ³	Lake Decatur . . .	19	5	26	57	15	26
May 16–29, 1940	Lake Chautauqua .	32	8	25	106	10	9
May 14–20, 1941	Lake Springfield . .	—	—	—	10	2	20

¹ Fish were designated as ripe if moderate pressure around vent resulted in extrusion of milt or sticky, translucent eggs.

² Lake Chautauqua, Mason County; Lake Decatur and Sangamon River, Macon County; Lake Springfield, Sangamon County.

³ Examination of anglers' catch.

⁴ Ovaries still noticeably enlarged in 9 females, ovaries much reduced in 16 females, classification intermediate or uncertain in 3 females.

⁵ Ovaries much reduced or immature in all females.

⁶ Some ripe males were found in this collection, but no complete count of ripe males was made. Of the total number of females taken, 81 were examined and the percentage of females ripe (5 to 10 per cent) was estimated immediately after the examination.

single empty ovary in a mature-size white crappie at the height of the spawning season in May and June is an indication that only part of the ripened contents of the ovary is voided in a single spawning act. Whether the white crappie female lays eggs in more than one nest was not learned.

The finding, in the latter half of the spawning season, of many white crappie females with enlarged but somewhat flabby ovaries, each containing large numbers of eggs, all opaque and unripe, suggests to the writer that an undetermined number of eggs, perhaps a considerable number, may be absorbed rather than laid.

Of another centrarchid, the bluegill, James (1946) reported, "Spawning appears to be intermittent during the summer months, but upon its completion resorption of the remaining eggs takes place. . . . Evidence of resorption could be seen in sectioned materials from late August until December."

As a general rule, the enlargement of the crappie ovary at or near spawning time is not sufficient to produce a noticeable bulging of the sides of the fish. In the

only instance the writer observed in which a large percentage of the female crappies had sides that bulged with eggs, the bulged condition was decidedly more prevalent in late April, in advance of the spawning season, than in late May, near the height of the spawning season. This observation was made on white crappies of about 11 inches and larger caught in hoop nets at Lake Chautauqua during the spring of 1940.

Nesting Habits

In common with all other centrarchids, crappies of both species guard their eggs and, like certain others, they do not invariably fan out nests. There is little uniformity in the sites they select.

Six white crappies, apparently nesting, were observed by the writer at Lake Springfield on May 26, 1941 (Hansen 1943). The six crappies, 6 to 7 inches in length, were in water 4 to 8 inches deep along an undercut sod bank of red clay. They were spaced 2 to 4 feet apart and were well concealed from the casual passer-by by the overhanging bank and by a

small elm tree that was growing in the water near the bank.

All six fish were moving the pectoral fins as if fanning eggs. They had not excavated nests, perhaps because the lake bottom at this place was hard and free of loose sediment. Close-range examination of the crappies and their surrounding territory failed to reveal eggs near four of the fish. Visible near one of the others were a few hundred eggs attached to dead blades of lawn grass and grass roots dangling in the water from the edge of the overhanging sod bank. The eggs were not more than 2 inches under the surface of the water; the fish guarding these eggs was actually below them. Guarded by another fish were at least a thousand eggs attached to a 3-inch ball of elm roots. The eggs averaged 0.89 mm. (0.034 inch) in diameter.

In 1940, L. J. Hoggatt, Springfield fisherman, found a single white crappie nest under the floor of a boathouse at Lake Springfield about 100 yards from the site of the writer's 1941 observations. In this case a thin layer of silt had been fanned away from a circular area 5 or 6 inches across, exposing a sandy bottom.

In line with the observation made above that probably only a small proportion of the eggs are deposited at one spawning act, the Lake Springfield fish observed in 1941 were guarding only a small fraction of the number of eggs which a female crappie is capable of producing. A similar situation was found among crappies which had spawned in a Washington, D. C., aquarium (Anonymous 1919). While egg counts have not been made on white crappie ovaries, Ulrey, Risk, & Scott (1938) made observations on numbers of eggs in black crappie ovaries which suggest the probable egg production of the white crappie. Their count showed from 27,000 to 68,000 eggs per black crappie female; the number of eggs depended on the age or size of the female examined. Eddy & Surber (1947) stated that a black crappie of 1½ pounds may have as many as 140,000 eggs in its ovaries.

There are similarities between nesting of the white crappies at Lake Springfield and published accounts of nesting of black crappies. The tendency of crappies to place their nests near some sort of vege-

tation is mentioned in various descriptions. In all cases where eggs of either species have been found they were attached to plant material. Considerable variation has been observed in depth of the water over the nests (from a few inches to 20 feet), in kinds of substrata (mud, clay, rock, sand, gravel, and concrete), and in distance of the nests from the shore.

At Havana, Illinois, Richardson (1913) found a black crappie nest hollowed out under the leaves of a water parsnip in water 10 inches deep. Other plants surrounding the nest included smartweed and bog rush. Most of the eggs were seen on the leaves of the water parsnip 2 to 4 inches above the bottom of the nest; others adhered to fine roots in the bottom of the nest.

Pearse (1919) found a number of black crappie nests at Lake Wingra, Madison, Wisconsin, along the edge of an undercut clay bank in water 2 feet deep; the nests were adjacent to an unidentified, submerged, aquatic plant.

At Lake Maxinkuckee, Indiana, Evermann & Clark (1920) found black crappies nesting on the sand and gravel bars at depths of 8 to 10 feet and shallower, the nests usually surrounded by chara. They gave the diameters of the nests as 8 to 9 inches.

Eddy & Surber (1947) wrote of the spawning of black crappies in Minnesota: "The nests are often close together and are sometimes built on bottoms that are softer and muddier than those usually chosen by members of this family."

An instance of crappie spawning at the Bureau of Fisheries Aquarium at Washington, D. C., is described in the magazine *Aquatic Life* (Anonymous 1919). The pair of fish involved had been at the aquarium for a number of years. Spawning occurred some time during the night of May 25. An estimated 6,000 eggs, some practically at the surface, were attached to algae, which formed a dense growth on the stones covering the steeply inclined back wall of the tank. The first young were seen on the morning of May 28 and all fertile eggs had hatched by May 31. As pointed out by Breder (1936), the *Aquatic Life* reference to the fish as a crappie rather than as a calico bass, or any other name for the black crappie, suggests

that the white crappie was probably the species under observation.

Nelson (1941) mentions that crappies (species not identified) spawned on cowlot manure straw in federal hatchery ponds at Elephant Butte, New Mexico. In letters to the writer, Mr. Nelson has given further details on crappie nesting both in these hatchery ponds and in nearby Elephant Butte Lake. In the ponds he observed that nesting was carried on in the open at water depths of $2\frac{1}{2}$ to 5 feet; that the crappies nested in colonies; that the nests were scooped out, though not as deeply as those of other sunfishes; that the eggs were attached to straw (from the fertilizer), to "chara or other moss," but that the crappies sometimes spawned where there was nothing whatever for egg attachment; that the crappies did not use the gravel beds that were available in the ponds. Nelson observed quite different nesting sites at Elephant Butte Lake, where in clear water he had seen crappies nesting at depths of 10 to 20 feet, "on rocks, boulders, submerged brush and trees, but never on sand or gravel bars or beaches." Presumably he referred to white crappies, as Greenbank (1937) found no black crappies in Elephant Butte Lake during his net-fishing studies.

Over a period of 6 to 7 years, the writer interviewed a considerable number of persons in an effort to gather more information on spawning habits of crappies in Illinois. Only five persons among those questioned had observed the nesting of crappies. Mr. Hoggatt's observation on nesting at Lake Springfield has already been mentioned. None of the other four observers knew which species of crappie had been observed.

At Scott's Pond, near Mount Zion, Illinois, Paul S. Smith of that place observed a 12-inch crappie guarding a nest situated on the submerged top of a concrete retaining wall for an earth dam. The nest was somewhat concealed by surrounding vegetation.

An engineer at Staley's pumping station on Lake Decatur believed he had seen crappies in the act of spawning along the submerged sloping concrete facing at the foot of the Baltimore & Ohio Railroad embankment 15 feet from the pumping station. This concrete facing supported a

growth of filamentous algae to which the engineer believed the eggs were attached. The situation in this instance was similar in important respects to that at the Washington Aquarium.

Frank Rhodes said that crappies at Beaverdam Lake spawned among aquatic plants along a shaded stretch of shore in water 1 to 2 feet deep. The fish had fanned away sediment to expose fine gravel or clumps of roots of nearby trees.

Anthony Kuderka of Taylor Springs, Illinois, saw crappie nests at Taylor Springs Lake on various occasions. He observed the nests in clear water near shore at a depth of about 2 feet. He described the nests as less deeply excavated than those of bluegills and always located near water plants.

As yet there have been no descriptions of nest building operations of crappies, nor has anyone described their mating behavior. Little is known about the behavior of the fish while guarding the nests. More information is needed on numbers of eggs deposited in nests and on losses of eggs because of predation or disease. The fact that nesting of crappies is not more often observed may be due to a preference for nesting sites within the concealment offered by water weeds, overhanging trees, undercut banks, and man-made structures. The turbid condition of most Illinois lakes in the spring is a hindrance to observation, and it is possible that the crappies usually nest in deeper water than that selected by the more frequently observed members of the sunfish family.

Sex Ratios

Sex ratios calculated for white crappies studied in Illinois varied with age and length of the fish, season of take, and method of capture.

Sex Ratios and Differential Survival of the Sexes.—In the Lake Decatur net samples, table 10, most of the young crappies were males and most of the older ones were females. Apparently, equality in sex ratio was present only from about the end of the second to about the end of the third year of life. It is not known to what extent the unbalanced sex ratio in these young crappies may have been the result of selectivity of the hoop nets.

Taken at face value the figures showing predominance of males among the two youngest broods could mean either that more males than females were hatched in these particular broods, or that the young females were subject to heavier early mortality than the young males.

Among older fish, on the other hand, the predominance of females over males

was so great as to leave little doubt that after about the third year males die off much faster than females.

While it appears in table 10 that sex ratios shift as the fish become older, the possibility must be kept in mind that some broods may start out with a predominance of males and other broods with a predominance of females.

Table 10.—Ratios of males to females in Lake Decatur white crappies of different ages. All collections made with 1-inch-mesh hoop nets.

AGE OF BROOD AT MIDPOINT OF STUDY, MONTHS	BROOD	PERIOD OF STUDY		NUMBER EXAMINED OF BOTH SEXES	MALES	FEMALES	MALES PER 100 FEMALES
		July 31, 1936- July 16, 1937 (11½ Months)	Nov. 4, 1938 Jan. 9, 1939 (2 Months)				
18	1937		x	126	78	48	163
20	1935	x		557	321	236	136
31	1936		x	89	38	51	74
32	1934	x		783	350	433	81
44	1933	x		179	63	116	54
60	1932	x		12	0	12	0
73	1931	x		9	0	9	0
83	1930	x		3	1	2	50

* Brood ages were computed from an assumed June 1 hatching date.

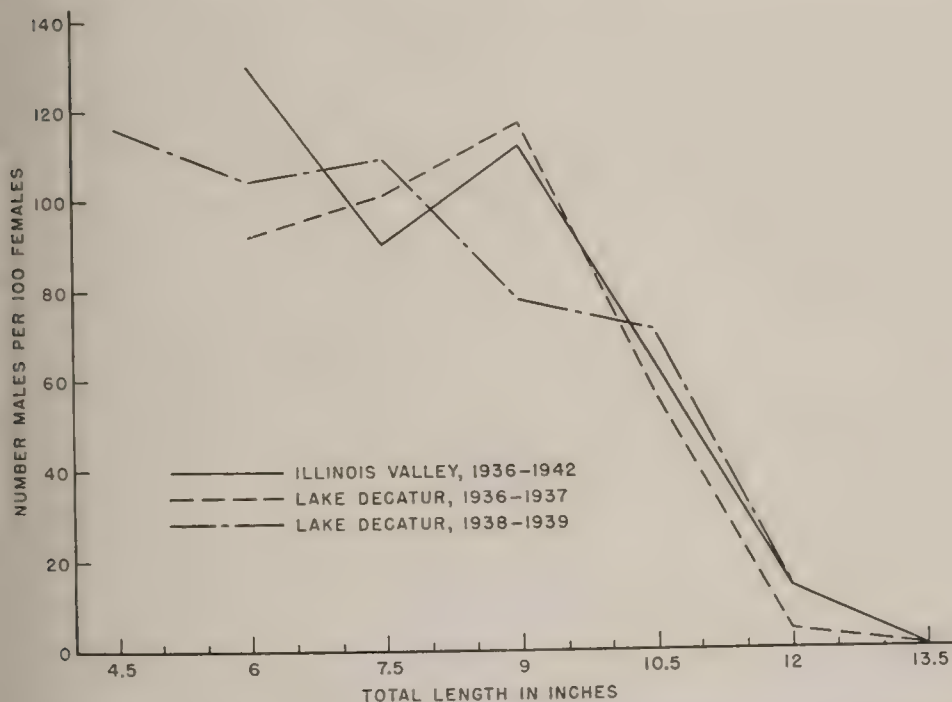


Fig. 5.—Changes in sex ratio of white crappies of different length classes. Data from Lake Decatur and from bottomland lakes of the Illinois River valley.

Corresponding somewhat with a change in sex ratios among crappies of different age classes is a change in sex ratios among

crappies of different size classes. Collections from Lake Decatur and the Illinois River valley show a fairly well-defined

Table 11.—Ratios of males to females in white crappies of various lengths, as determined by observations on fish collected at Lake Decatur and in bottomland lakes of the Illinois River valley. All collections made with 1-inch-mesh hoop nets.

TOTAL LENGTH CLASS, INCHES*	LAKE DECATUR						ILLINOIS RIVER VALLEY		
	July, 1936, to July, 1937			Nov., 1938, to Dec., 1939			Males	Females	Males per 100 Females
	Males	Females	Males per 100 Females	Males	Females	Males per 100 Females			
4½.....	0	1	—	103	89	116	1	0	—
6.....	25	27	92	366	351	104	43	33	130
7½.....	132	131	101	470	430	109	75	83	90
9.....	446	380	117	219	280	78	139	124	112
10½.....	190	331	57	59	83	71	64	102	63
12.....	1	25	4	6	45	13	6	46	13
13½.....	0	6	0	0	14	0	0	4	0
15.....	—	—	—	—	—	—	0	1	—

* Class center is indicated; the 4½-inch class includes fish of 3.8 through 5.2 inches total length; the 6-inch class includes fish of 5.3 through 6.7 inches.

Table 12.—Ratios of males to females in white crappies taken in different months, as observed in entire hoop-net catches at Lake Decatur.

DATE OF COLLECTION	NUMBER OF SPECIMENS	MALES	FEMALES	MALES PER 100 FEMALES
<i>1936</i>				
May 29–June 4.....	100	37	63	59
July 3–5.....	45	17	28	61
July 31–Aug. 3.....	82	43	39	110
Sept. 8–22.....	88	52	36	144
Oct. 24–27.....	228	119	109	109
Dec. 21.....	295	153	142	108
<i>1937</i>				
March 1–4.....	297	150	147	102
April 24.....	115	41	74	55
June 3–5.....	225	91	134	68
June 24.....	133	52	81	64
July 10–16.....	84	38	46	83
<i>1938</i>				
Nov. 4–11.....	73	37	36	103
<i>1939</i>				
Jan. 9.....	153	87	66	132
March 24.....	315	156	159	98
May 3.....	146	75	71	106
May 29.....	118	39	79	49
June 20.....	135	70	65	108
July 13–17.....	313	165	148	111
Aug. 24.....	80	44	36	122
Oct. 16.....	266	134	132	102
Dec. 11.....	817	402	415	97
<i>Total.....</i>	<i>4,108</i>	<i>2,002</i>	<i>2,106</i>	<i>95</i>

shift in sex ratios from a preponderance of males among small crappies to a preponderance of females among large ones, table 11 and fig. 5.

In the longear sunfish, *Lepomis megalotis peltastes*, studied by Hubbs & Cooper (1935), the age-sex ratio trend was similar to that of the white crappie of Lake Decatur, although the preponderance of females among the older longear sunfish was restricted to fish in the fifth summer. In the green sunfish, *L. cyanellus*, studied by Hubbs & Cooper (1935), in the bluegill, *L. macrochirus*, studied by Schoffman (1938), and in the redear sunfish (western shellcracker), *L. microlophus*, studied by Schoffman (1939), collections of older fish tended to be predominantly male.

Seasonal Variations in Sex Ratios of Fish Taken in Hoop Nets.—In the white crappies of Lake Decatur, the date of sampling appeared to have a bearing on the calculated sex ratio, table 12 and fig.

6. In most fall, winter, and early spring collections, males were more numerous than females, while in most late spring and early summer collections males were less numerous than females. A drop in the relative numbers of males approximately paralleling that seen at Lake Decatur in the spring of 1939 was observed in the hoop-net samples at Lake Chautauqua in the spring of 1940, as follows: a sample of 152 white crappies caught April 24 and 25 showed a ratio of 127 males per 100 females, while a sample of 503 specimens taken May 22–28 showed a ratio of only 26 males per 100 females. This spring-summer scarcity of males might be expected to have been the result of the more prolonged involvement of the males with nest construction and guarding. However, reference to fig. 6 shows that in certain years the period of male scarcity at Lake Decatur was somewhat longer than the major spawning season.

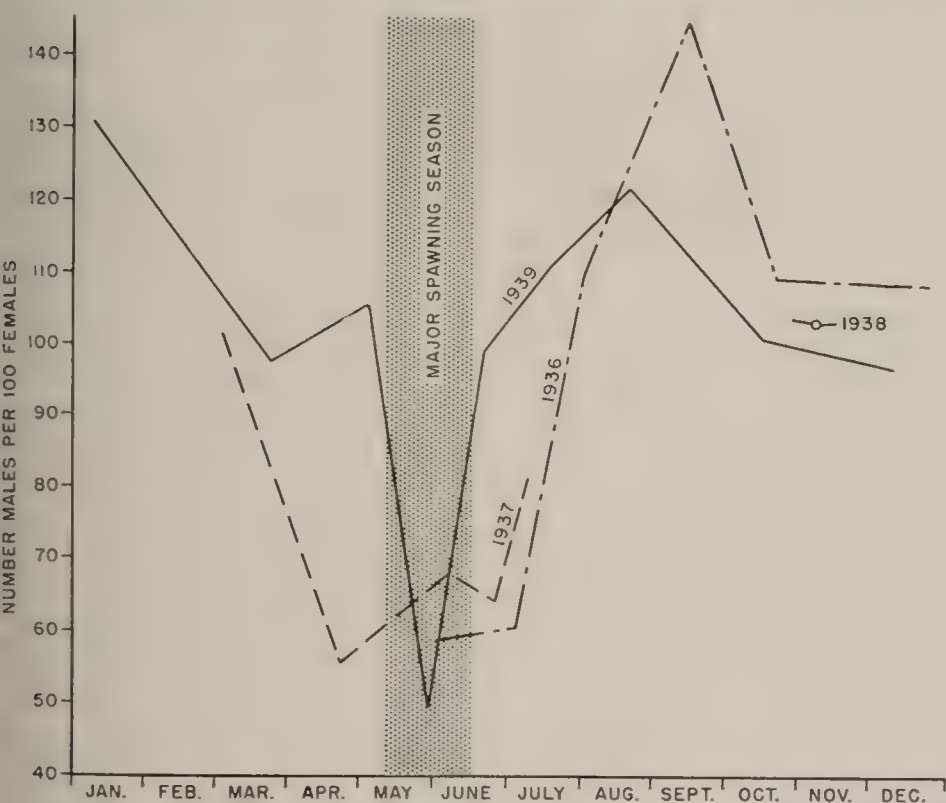


FIG. 6.—Seasonal variation in sex ratio for entire samples of white crappies collected during different years at Lake Decatur. Only one observation on sex ratio was made in 1938.

Because of the comparatively short life-span of broods, table 20, a new brood in the net catches generally made up an important percentage of the total sample. It is worth while to consider that, if the members of a new brood entering the net samples were predominantly one sex or the other, it would have an important effect on the sex composition of the catch as a whole. In the Lake Decatur sampling, second-year fish that first entered the net catches in 1936 and 1938 at ages of 13-17 months were predominantly male, table 10, a fact that may partially explain the predominance of males in some of the entire net catches recorded in table 12. When a preponderance of females appears in collections made before another new brood is taken in the nets, it may be explained by a generally higher mortality rate among males that, data indicate, occurs some time after the middle of the second year.

Variations in Calculated Sex Ratios Resulting From Inadequate Sampling.—Inadequate sampling of fish populations may result in calculated sex ratios that fail to reflect the actual ratios in the populations sampled.

The following is an example of sex ratio variation which may arise even when the samples are large. At Lake Chautauqua in 1940, a striking difference in sex ratios was observed in samples taken on consecutive days: from a ratio of 14 males per 100 females on May 22 to a ratio of 51 males per 100 females on May 23. The locations of the nets were slightly different on the 2 days. The ratios were calculated from 308 fish the first day and 186 the second.

Sex Ratios in Two Hook-and-Line Catches.—Two observations on the sex of white crappies taken by hook and line were made at Lake Decatur. In each observation, males were much less numerous than females. On May 16, 1937, when scales and measurements were taken from 86 fish, it was estimated on the basis of breeding color that not more than 10 per cent of the 86 fish were males. On May 17-20, 1939, when 100 fish taken by anglers were sexed by gonad examination, the ratio was found to be 20 males to 80 females. In terms of number of males per 100 females, the sex ratios in these two catches were 11 and 25, respectively. A

comparison of these ratios with those in table 12 will show that males were relatively scarcer in the anglers' catches than in any of the hoop-net catches at Lake Decatur.

DISEASE

The virus disease, lymphocystis, which appears in the form of white, granular, irregularly shaped lumps on the fins and bodies of fish, is the only disease known to occur commonly in Illinois crappies. It is found in both the white crappie and black crappie. An individual lump may cover as much as half a square inch of surface. In diseased fins the ends of the rays are sometimes missing, but the disease is not known to be fatal.

In counts made on fish from bottomland lakes in the Illinois River valley, lymphocystis was found in 1.4 per cent of the white crappies caught at Senachwine Lake, April 29, 1942, in 9.5 per cent of those caught at Lake De Pue, April 25-27, 1942, and in 19.5 per cent of those taken at Lake Chautauqua, September 17-18, 1943.

Some of the more recent investigations on lymphocystis are those of Nigrelli & Smith (1939) and Weissenberg (1939). Weissenberg has shown that the granular appearance of the lumps is due to enlargement of connective tissue cells.

ABNORMALITIES

The principal abnormalities observed in the white crappie relate to color and structure. Excessive slime production was observed in one locality.

Color and Structure

Usually the white crappie is easily distinguished from the black crappie on the basis of coloration. In the white crappie, the dark markings on the sides tend to form faint vertical bars or rings, while in the black crappie the dark markings produce an over-all mottling. It has been the experience of the writer to find rather frequent departures from these characteristic patterns in crappies smaller than 4 inches and larger than 10 or 11 inches. In many of these individuals, the dark markings are

not arranged in a manner that allows for positive species separation on the basis of color pattern alone.

Structural freaks among crappies have been observed by the writer a number of times. Many of these have the low angle of the mouth of the white crappie but the deep body and pigmentation of the black crappie. No observation was made on these specimens of the number of dorsal spines—usually different in white crappies and black crappies.

Humpbacks and foreshortened bodies, both resulting from disease of the spine, are conditions that have occasionally been seen in the white crappie as well as in other species of Illinois fish.

Excessive Sliminess

A heavy coating of mucus was observed by the writer in a large percentage of both white crappies and black crappies taken during fishing operations at Lake Chautauqua on April 10, 1941. The mucus tended to foam when the fish were emptied from the nets into the boat and made the fish unusually slippery in handling. This was the only occasion when excessive mucus was observed on crappies, but the condition was observed in the gizzard shad

Table 13.—Standard lengths and equivalent total lengths of white crappies. From a graph based on the measurements of 96 white crappies taken at Horseshoe Lake, Alexander County, Illinois, February 22-28, 1938. See section "Methods and Techniques" for definitions of standard length and total length.

STANDARD LENGTH, INCHES	TOTAL LENGTH, INCHES
2.0	3.0
2.5	3.5
3.0	4.1
3.5	4.7
4.0	5.3
4.5	5.9
5.0	6.5
5.5	7.1
6.0	7.7
6.5	8.3
7.0	8.9
7.5	9.5
8.0	10.1
8.5	10.7
9.0	11.3
9.5	11.9
10.0	12.5

caught at Lake Chautauqua on September 17 and 18, 1943. The cause of this abnormal secretion of mucus was not determined.

CONDITION OR PLUMPNESS

The coefficient of condition, K, representing relative plumpness was computed for white crappies from Lake Decatur and three other Illinois lakes by means of the formula:

$$K = \frac{\text{Weight in grams}}{\text{Standard length in centimeters}^3} \times 100$$

Length classes in this part of the paper are presented in terms of standard length rather than total length. Equivalent measurements in inches for standard and total lengths of white crappies are given in table 13. Original length and weight measurements in inches and pounds were converted to centimeters and grams as necessary for the computation of K values.

Seasonal Changes in K Values

This discussion, emphasizing seasonal variation in K values, is based on the collections made at Lake Decatur between April 3, 1936, and January 9, 1939. The build of the Lake Decatur crappies at the time of these observations appeared to be fairly typical of the build of crappies usually seen in Illinois; the seasonal changes in plumpness were not noticeable in the build of the fish. The average K values for members of various length classes appear for each collection date in table 14. The seasonal trends in average K values for the most abundantly represented length classes can best be followed in fig. 7. Some of the unevenness in the curves is quite obviously due to an insufficiency of specimens in some length classes.

That an average K value based on a small sample might not be truly representative of a length class is apparent from the wide spread of K values found among different individuals of a length class on the same date, table 15. The K values for two dates are shown in this table.

In describing seasonal changes in plumpness, it is necessary to make separate mention of the changes in large and small

Table 14.—Seasonal fluctuations in the coefficient of condition (K) in Lake Decatur white crappies of different standard length classes. Some of these data are plotted in fig. 7. Figures in parentheses represent numbers of specimens.

DATE OF COLLECTION	STANDARD LENGTH, INCHES ¹										
	3	4	5	6	7	8	9	10	11		
1936											
April 3.....	2.34 (3)	2.23 (101)	2.37 (85)	2.77 (77)	2.93 (42)	3.10 (16)	3.11 (1)	—	—	—	—
May 4-10.....	—	2.45 (25)	2.42 (15)	2.78 (26)	2.99 (12)	2.93 (2)	3.16 (4)	3.23 (2)	—	—	—
May 29-June 4.....	—	2.66 (5)	2.63 (17)	2.67 (37)	2.77 (25)	2.80 (12)	2.81 (2)	3.03 (3)	—	—	—
July 3-5.....	—	3.20 (2)	3.00 (11)	3.01 (26)	2.88 (3)	2.76 (2)	—	—	—	—	—
July 31-Aug. 3.....	—	2.65 (4)	2.87 (45)	3.03 (13)	3.04 (18)	2.57 (1)	—	—	—	—	—
Sept. 8-14.....	2.66 (2)	2.94 (1)	2.88 (3)	3.02 (11)	3.17 (8)	3.33 (4)	—	—	—	—	—
Sept. 22.....	—	—	2.62 (5)	2.98 (36)	3.06 (14)	3.04 (6)	—	—	—	—	—
Oct. 24-27.....	—	2.12 (1)	2.17 (2)	2.78 (21)	3.02 (95)	3.24 (107)	3.43 (11)	—	—	—	—
Dec. 21.....	—	—	2.79 (1)	2.96 (37)	3.17 (165)	3.29 (88)	3.48 (4)	—	—	—	—
1937											
March 1-4.....	—	—	2.08 (1)	2.84 (48)	3.03 (116)	3.26 (162)	3.37 (17)	3.00 (1)	3.26 (1)	—	—
April 24.....	—	—	2.31 (3)	2.57 (12)	2.90 (36)	3.09 (63)	3.31 (3)	—	—	—	—
May 16 ²	—	—	—	2.64 (4)	2.96 (44)	3.08 (33)	3.14 (5)	—	—	—	—
June 3-5.....	—	—	2.40 (3)	2.62 (26)	2.69 (75)	2.77 (103)	2.93 (16)	2.95 (2)	—	—	—
June 24.....	—	2.74 (4)	2.58 (1)	2.67 (9)	2.70 (37)	2.76 (71)	2.74 (12)	2.83 (4)	2.94 (2)	—	—
July 10-16.....	—	2.66 (6)	2.28 (2)	2.62 (11)	2.68 (34)	2.62 (35)	2.56 (2)	2.69 (4)	—	—	—
Aug. 6-14.....	—	2.67 (12)	2.71 (33)	2.76 (6)	2.86 (11)	2.91 (7)	3.06 (2)	—	—	—	—
Sept. 22.....	—	2.58 (12)	2.55 (149)	2.63 (47)	2.84 (5)	3.08 (3)	3.17 (1)	—	—	—	—
Nov. 3.....	—	2.41 (22)	2.43 (123)	2.61 (19)	2.97 (4)	3.17 (2)	—	—	—	—	—
1938											
Jan. 17-24.....	—	—	2.42 (11)	2.64 (1)	2.77 (1)	—	3.31 (2)	3.43 (2)	—	—	—
March 14.....	—	2.33 (24)	2.32 (12)	2.63 (41)	2.93 (12)	3.19 (13)	3.37 (8)	3.40 (1)	3.38 (1)	—	—
May 28.....	—	2.21 (35)	2.21 (40)	2.42 (8)	2.73 (3)	2.98 (4)	3.02 (8)	3.14 (2)	—	—	—
July 14.....	2.81 (1)	2.56 (21)	2.52 (6)	—	—	—	3.46 (1)	—	—	—	—
Aug. 25.....	2.79 (2)	2.48 (25)	2.66 (33)	2.78 (12)	2.78 (3)	3.29 (1)	2.96 (1)	—	—	—	—
Oct. 6.....	—	2.29 (1)	2.50 (18)	2.75 (39)	3.02 (8)	3.25 (3)	—	—	—	—	—
Nov. 4-11.....	—	2.41 (1)	2.35 (14)	2.73 (26)	2.93 (17)	3.08 (13)	3.18 (2)	3.11 (1)	—	—	—
1939											
Jan. 9.....	2.23 (1)	2.22 (5)	2.33 (14)	2.75 (45)	3.04 (64)	3.18 (21)	3.31 (3)	3.06 (1)	—	—	—

¹ Class center; for example, the 6-inch class includes fish of 5.6 through 6.5 inches in length.

² Sample obtained from anglers.

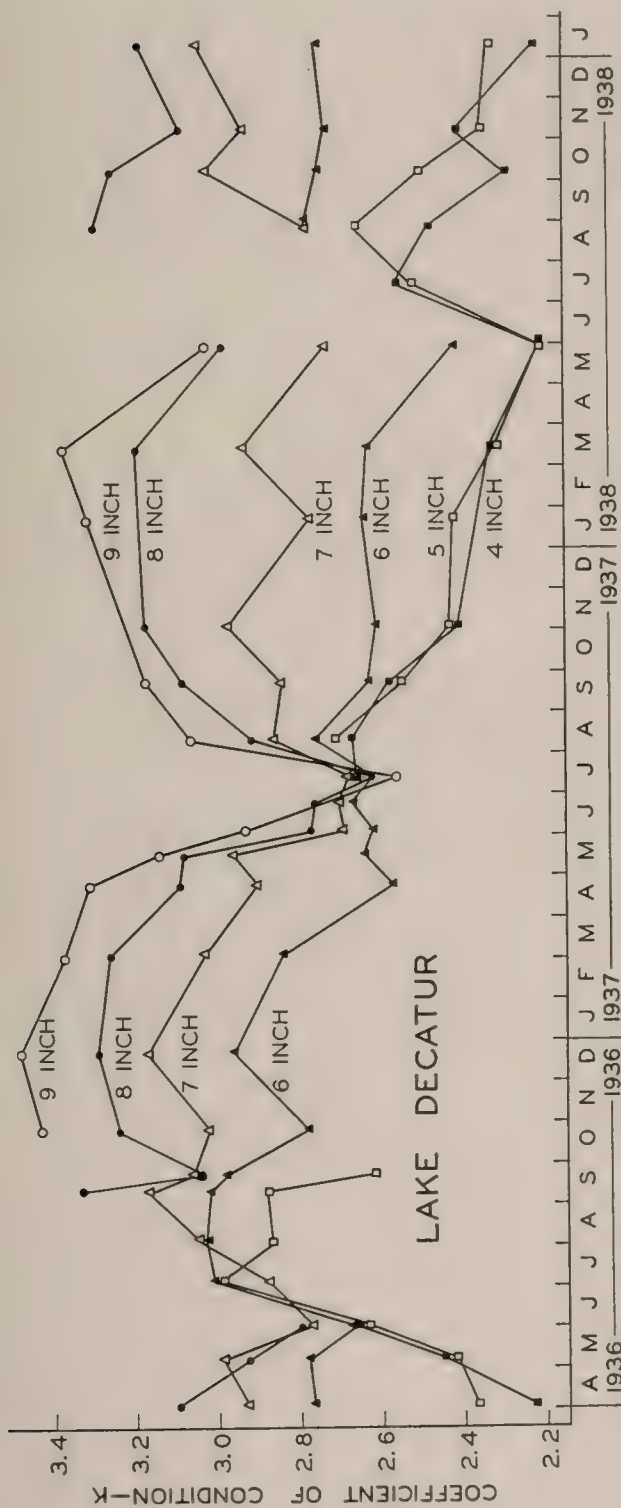


Fig. 7.—Seasonal fluctuations in the coefficient of condition (K) for white crappies of different length classes at Lake Decatur. (Data from table 14.)

crappies. White crappies over 7 inches (standard length) may be regarded as mature and those under 5 inches as immature. The seasonal changes may be summarized as follows:

Large sizes, crappies 7 inches standard length and smaller: Condition values increased rapidly through middle and late summer, reached a yearly peak in late fall or early winter, remained at a high level through the cold months, dropped sharply during the spring, and reached the lowest point in early summer.

Small sizes, crappies 5 inches standard length and smaller: Condition values increased from the middle of spring through early summer, reached a yearly peak in midsummer, fell off through late summer and fall, remained stationary through the cold months, and fell again through early spring.

Condition changes of crappies in the 6-inch class were approximately intermediate between changes described for fish of the two size classes discussed above.

Differences between large and small fish with respect to condition changes may be summarized as follows: The small crappies began to fatten earlier in the growing season than the large crappies, reached peak condition in midsummer rather than late fall or early winter, and lost condition in spring and again in late summer and fall, rather than only in the spring and early summer.

In fish that were less than 5 inches long at the start of the growing season and that grew to a length greater than 7 inches, the fall and subsequent spring changes in condition followed those described for the larger fish.

Increases in K values occurred only during the annual growing period.

Upward and downward trends in large and small fish described above for various seasons of the year have, for the most part, been based on observations made during 2 calendar years. The evidence of winter-to-spring drop in condition in large fish rests mainly on observations in 1937 when large sizes were abundant; winter observations were lacking for 1935-36, and large fish were scarce in the first half of 1938.

Fish of given sizes did not always show the same K values in corresponding

months of different years. The 8-inch and 9-inch classes showed more uniformity in this respect than the smaller fish.

A tendency for large fish to have higher K values than small ones was observed in the smallmouth bass by Bennett (1938), in the largemouth bass by Thompson & Bennett (1939), and in the bluegill by Bennett, Thompson, & Parr (1940). Such a relationship was also found in the Lake Decatur white crappies but was unapparent or inconspicuous at certain times of the year—especially in June and July. The similarity of K values in all sizes of white crappies at that time of year may be ascribed to two things: (1) Late winter and early spring weight losses were relatively greater in large fish than in small ones (compare the changes in K values in the 6-inch to 9-inch classes from March to June, 1937) and (2) summer gains in K values started earlier in small fish than in large ones. Adequate data on the spread of K values are not available for June and July, 1938, because no collecting was attempted in June, and the July collection included only a few large fish.

A limited number of comparisons between K values of males and females of various lengths, table 16, indicates that the seasonal changes in condition occur in both sexes and that throughout the year K values tend to be a little higher in males than in females. Stroud (1948) found no important difference in plumpness between the sexes of black crappies in Norris Reservoir, Tennessee.

In black crappie collections made at several different times of year, Stroud (1948) did not find important differences in plumpness among four age categories or among size groups ranging from 4 to 12 inches. The failure of his data to show important differences is perhaps explained by the fact that most of his collecting was done in the spring, which, as indicated by observations at Lake Decatur, is a time of year when large and small crappies are of similar plumpness.

Changes in the average K value for members of various broods taken in the nets between early April, 1936, and early January, 1939, may be seen in table 17 and fig. 8. Broods represented in the nets by only a few specimens have been omitted from the table and graph. The longest

period of observation of any brood was about 2 years. A certain amount of resemblance may be seen between the curves in figs. 7 and 8. In general, the seasonal

Table 15.—Examples of the distribution of coefficient of condition (K) in white crappies of four size categories, 6-9 inches standard length, at Lake Decatur, March 1-4, and June 24, 1937. These dates were arbitrarily selected.

K VALUE	STANDARD LENGTH* OF FISH COLLECTED, MARCH 1-4, 1937				STANDARD LENGTH* OF FISH COLLECTED, JUNE 24, 1937			
	6 Inches	7 Inches	8 Inches	9 Inches	6 Inches	7 Inches	8 Inches	9 Inches
2.0.....	—	—	—	—	—	—	—	1
2.1.....	—	—	—	—	—	—	—	—
2.2.....	—	—	—	—	—	1	—	—
2.3.....	—	—	—	—	—	—	1	—
2.4.....	1	—	—	1	—	2	3	—
2.5.....	—	—	—	—	2	4	8	—
2.6.....	11	2	—	—	2	8	6	2
2.7.....	9	5	—	—	3	8	14	3
2.8.....	5	11	2	—	2	7	16	4
2.9.....	11	27	6	—	—	6	16	1
3.0.....	4	16	11	1	—	1	7	3
3.1.....	4	23	23	—	—	—	—	—
3.2.....	2	11	39	—	—	—	1	—
3.3.....	—	16	24	3	—	—	1	—
3.4.....	—	2	30	6	—	—	—	—
3.5.....	1	1	16	3	—	—	—	—
3.6.....	—	1	7	2	—	—	—	—
3.7.....	—	1	3	1	—	—	—	—
Total.....	48	116	161	17	9	37	71	12
Average K.....	2.84	3.03	3.26	3.37	2.67	2.70	2.76	2.74

* Class center; for example, the 6-inch class includes fish of 5.6 through 6.5 inches in length.

Table 16.—Coefficient of condition (K) in Lake Decatur white crappie males and females of different length categories. Values of K were not computed where the sexes were not represented by at least 16 specimens. Figures in parentheses represent numbers of specimens.

DATE OF COLLECTION	STANDARD LENGTH* AND SEX							
	5 Inches		6 Inches		7 Inches		8 Inches	
	Male	Female	Male	Female	Male	Female	Male	Female
1936								
May 29-June 4	—	—	2.69 (16)	2.64 (19)	—	—	—	—
July 31-Aug. 3	2.95 (26)	2.88 (19)	—	—	—	—	—	—
Oct. 24-27.....	—	—	—	—	3.09 (51)	2.94 (37)	3.29 (53)	3.19 (52)
Dec. 21.....	—	—	2.90 (18)	3.00 (20)	3.20 (94)	3.12 (72)	3.31 (38)	3.25 (50)
1937								
March 1-4.....	—	—	—	—	3.04 (66)	3.01 (36)	3.27 (69)	3.25 (86)
April 24.....	—	—	—	—	3.01 (16)	2.82 (20)	3.16 (18)	3.05 (45)
June 24.....	—	—	—	—	2.78 (20)	2.60 (17)	2.85 (26)	2.71 (45)
July 10-16.....	—	—	—	—	2.77 (16)	2.57 (16)	—	—
1939								
Jan. 9.....	—	—	2.74 (23)	2.75 (22)	3.00 (37)	2.97 (28)	—	—

* Class center; for example, the 6-inch class includes fish of 5.6 through 6.5 inches in length.

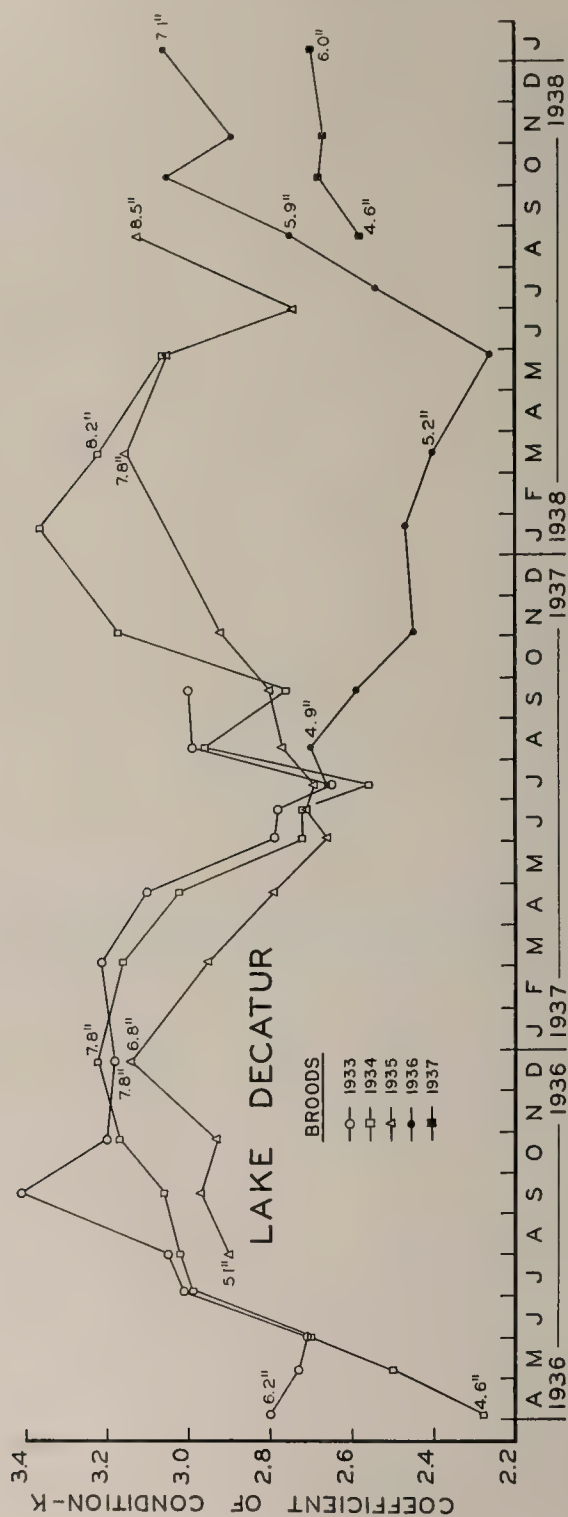


Fig. 8.—Seasonal fluctuations in the coefficient of condition (K) for white crappies belonging to various broods hatched at Lake Decatur, 1933-1937. The major changes in average lengths of individuals of the broods during the period of observations may be seen in the length figures which appear at intervals along the curves. (Data from table 17.)

fluctuations in condition summarized for small fish were similar to those occurring in young fish, and the fluctuations summarized for large fish were similar to those occurring in old fish. Differences in condition between adjoining broods were, as a rule, small, unless members of the adjoining broods differed considerably in length.

Late-summer trends in condition were especially variable from year to year in second-year fish, fig. 8. A late-summer rise in condition was observed in broods making good or moderately good late-summer growth (1935 brood in 1936, and 1937 brood in 1938), but a late-summer loss of condition was observed in a brood whose late-summer growth was small (1936 brood in 1937). The amount of late-summer growth can be seen from the average lengths of fish printed along the curves in fig. 8. With reference to the condition

changes in the 1935 brood in late summer of 1936 and the 1937 brood in late summer of 1938, it is apparent that while each brood, taken as a whole, showed a rise in condition, fig. 8, the smaller (4-inch and 5-inch fish, fig. 7) were losing condition.

Eschmeyer, Stroud, & Jones (1944) observed condition changes in white crappies which they refer to as 2-year-olds (apparently the 1940 brood) at Chickamauga Reservoir, Tennessee, from March to October, 1942. This brood of white crappies reached peak condition in June and showed little change in condition from June to October, thus following the trends observed in Lake Decatur crappies of similar age and making the same sort of poor late-summer growth.

Measurements of condition of white crappies in three other Illinois lakes may be seen in table 18. Generally, fish from

Table 17.—Seasonal fluctuations in average coefficient of condition (K) in several broods of Lake Decatur white crappies. Figures in parentheses represent numbers of specimens.

DATE OF COLLECTION	1933 BROOD	1934 BROOD	1935 BROOD	1936 BROOD	1937 BROOD
<i>1936</i>					
April 3.....	2.80 (152)	2.28 (168)	—	—	—
May 4-6.....	2.73 (18)	2.50 (44)	—	—	—
May 29-June 4.....	2.71 (59)	2.70 (24)	—	—	—
July 3-5.....	3.01 (5)	2.99 (36)	—	—	—
July 31-Aug. 3.....	3.05 (4)	3.02 (27)	2.90 (51)	—	—
Sept. 8-14.....	3.47 (2)	3.15 (11)	2.99 (14)	—	—
Sept. 22.....	3.28 (1)	2.97 (11)	2.97 (49)	—	—
Oct. 24-27.....	3.20 (17)	3.17 (139)	2.93 (69)	—	—
Dec. 21.....	3.18 (18)	3.22 (107)	3.14 (171)	—	—
<i>1937</i>					
March 1-4.....	3.21 (53)	3.16 (220)	2.95 (67)	—	—
April 24.....	3.10 (14)	3.02 (67)	2.79 (35)	—	—
May 16*.....	3.02 (10)	3.07 (39)	2.93 (37)	—	—
June 3-5.....	2.79 (32)	2.72 (116)	2.66 (62)	—	—
June 24.....	2.78 (27)	2.72 (73)	2.71 (27)	—	—
July 10-16.....	2.65 (15)	2.56 (37)	2.69 (29)	2.66 (6)	—
Aug. 6-14.....	2.99 (2)	2.96 (8)	2.77 (13)	2.70 (45)	—
Sept. 22.....	3.00 (2)	2.76 (2)	2.80 (7)	2.59 (206)	—
Nov. 3.....	—	3.17 (2)	2.92 (3)	2.45 (165)	—
<i>1938</i>					
Jan. 17-24.....	—	3.36 (3)	—	2.47 (12)	—
March 14.....	—	3.22 (14)	3.15 (16)	2.40 (181)	—
May 28.....	—	3.06 (8)	3.05 (4)	2.26 (84)	—
July 1.....	—	—	2.74 (4)	—	—
July 14.....	—	—	—	2.54 (24)	—
Aug. 25.....	—	—	3.12 (2)	2.75 (19)	2.58 (56)
Oct. 6.....	—	—	—	3.05 (9)	2.68 (59)
Nov. 4-11.....	—	—	—	2.89 (17)	2.67 (49)
<i>1939</i>					
Jan. 9.....	—	—	—	3.06 (71)	2.70 (77)

* Sample obtained from anglers.

Table 18.—Average coefficient of condition (K) for various standard length groups of white crappies at Horseshoe Lake, Craborchard Lake, and Senachwine Lake. Figures in parentheses represent numbers of specimens.

LAKE	DATE	STANDARD LENGTH, INCHES*									
		4	5	6	7	8	9	10	11	12	
Horseshoe (Alexander County).....	Feb. 19-28, 1938...	—	2.75 (31)	2.48 (26)	2.42 (7)	2.76 (4)	3.12 (5)	3.03 (6)	3.32 (10)	3.17 (5)	
Craborchard (Williamson County).....	March 23, 1944...	—	—	—	—	3.70 (3)	3.66 (4)	4.18 (4)	4.03 (2)	—	
Senachwine (Putnam County).....	Aug. 18-31, 1933...	2.85 (16)	2.84 (38)	2.91 (8)	2.99 (3)	—	—	—	—	—	
	Sept. 1-16, 1933...	2.85 (11)	2.84 (19)	2.93 (11)	2.95 (5)	—	—	—	—	—	
	Sept. 21-29, 1933...	2.65 (8)	2.82 (44)	2.82 (13)	3.08 (9)	—	—	—	—	—	
	Oct. 1-13, 1933...	2.82 (4)	2.66 (35)	2.85 (24)	3.10 (14)	3.12 (4)	—	—	—	—	

* Class center; for example, the 6-inch class includes fish of 5.6 through 6.5 inches in length.

these lakes show an increase in K with increase in length. An exception may be cited in the Horseshoe Lake data, where the K value of the 5-inch class was considerably higher than the K values for the 6-inch and 7-inch classes.

The condition values of 13 white crappies taken at Craborchard Lake in March, 1944, were much higher than the values observed in crappies of the same size elsewhere in Illinois. In these Craborchard specimens, high condition had accompanied rapid growth. Craborchard Lake was new in 1939. These large Craborchard specimens were observed to be deep bodied in proportion to their lengths and unusually plump in their abdominal regions. The body cavities of dissected specimens contained exceptionally large deposits of fat. No such large deposits were seen in the white crappies of Lake Decatur. In the same Craborchard collections, fish of small sizes appeared to be much less plump than those of large sizes, but they were not weighed and their K values were not determined.

While working for the Natural History Survey at Senachwine Lake on July 31, 1933, Lyle E. Bamber measured and weighed 16 white crappies which ranged from 35 to 49 mm. (1.4 to 2.0 inches) standard length. From their lengths and the absence of annuli on their scales, they were judged to be about 2 months old. They were the only young-of-the-year crappies studied. Their K values varied from 2.01 to 2.46 (average 2.20). Length and weight measurements were made with the degree of accuracy desirable for such small fish, as described in the section "Methods and Techniques."

Collections of 4- to 7-inch white crappies measured at Senachwine Lake during the period August 18 to October 13, 1933, showed changes in condition that approximately corresponded with the autumn changes in condition in 4- to 7-inch crappies at Lake Decatur; the 4-, 5-, and 6-inch classes showed a loss in condition and the 7-inch class a slight rise in condition from August to October, table 18.

Possible Reasons for K Loss

The fact that spring was a time of sharp decline in plumpness of Lake Decatur

white crappies suggests a possible connection between weight loss and spawning. The major weight loss in mature white crappies occurred over a 2-month period preceding the nesting season. It appears likely that, in the years we are dealing with, most of the nesting took place within the period May 15 to June 15. Russell (1914) suggested that a prespawning condition loss in the haddock was caused by diversion of food materials to the ripening sex organs. But since two other species, the sardine studied by Clark (1928) and the bluegill studied by Bennett, Thompson, & Parr (1940), showed a rise in condition just before spawning and also since there was a spring loss of condition in immature crappies, it is appropriate to look for other explanations than the one offered by Russell.

Clark (1928), Mottley (1938), and Bennett, Thompson, & Parr (1940) all observed a loss in condition after spawning.

The condition losses in mature white crappies are too large to be accounted for by reduction in weight of the ovaries and testes after spawning. Weighing of the gonads of a few white crappies ranging from 6.5 to 10 inches standard length showed that just before the spawning season the ovary weight amounted to 6 per cent of the total body weight, and the testes weight amounted to less than 1 per cent of the total body weight, while the average winter-to-spring weight loss of the entire fish amounted to about 15 per cent in both sexes.

It was found, as already mentioned, that small white crappies underwent a loss in condition in late summer and fall when they were increasing slowly in length. The possibility can be disregarded that the spring condition loss of larger fish was brought about by growth in length of the crappies without sufficient gain in weight to maintain K values at a constant level. Annulus formation studies showed that only a few of the mature Lake Decatur white crappies had started their 1937 growth by early June, and that the majority delayed their 1937 growth until July or August. Thus, at the time of their spring loss in condition, the large crappies were not growing in length.

Other possible reasons for spring condition loss among white crappies include

disease, seasonal scarcity of fattening foods (or food in general), and difficult feeding conditions resulting from high turbidity. Disease as a possible reason for weight loss is suggested by the apparent high summer mortality of Lake Decatur crappies, a mortality indicated by low net catches in summer, table 20. No data are available on seasonal variations in crappie foods at Lake Decatur. It is not known that high turbidity in spring seriously interfered with crappie feeding. On the contrary, crappies caught in the spring of 1937 seemed to be having considerable success in capturing gizzard shad.

The reason for late-summer loss of condition in small crappies remains as obscure as the reason for their condition loss in the spring.

AGE AND GROWTH

The uses to which growth data on fish may be put depends in large measure on the accuracy of age determinations. In many instances, annual rings on the scales of white crappies appear to give only approximations of age, and the practical application of the scale method of age determination in these fish has been limited in Illinois mainly to detection of stunted populations.

Age Determination

Evidence was obtained at Lake Decatur during studies on date of annulus formation in white crappies that the age rings, fig. 9, are not invariably formed at the rate of one ring for each year of life nor at exactly the same time of year. This evidence may be summarized as follows:

1. In 1935 and 1937 some individuals failed to form annual rings because they did not grow in those years. While the observed cases of failure to form these rings appeared to include only a small proportion of the total population, there seemed to be a possibility that the percentage of cases was high in certain broods.

2. In the collection of September, 1937, 65 per cent of the members of the 1936 brood had two annuli, one of which was necessarily false. The false annulus, or the one thought to be false, while comparatively inconspicuous in some individ-

uals, was well defined in others; some annuli showed cutting-over similar to that shown in fig. 9 and in other respects bore a close resemblance to the rings ordinarily considered to be true year marks.

3. In many scales collected at Lake Decatur the first annulus was indistinct and in some scales it was missing. Commonly the first annulus was present on some scales but absent on other scales of the same fish. A similar variation in visibility of supposedly first rings was commonly observed in collections from other Illinois localities.

4. Annulus formation occurred in different individuals at quite different times in the spring or summer from early May to late August, table 23. The over-all period in which different fish in the population were forming annuli lasted from 6 weeks in some years to 10 weeks or longer in other years.

White crappies collected during the period of annulus formation cannot be aged accurately by scale reading unless, under rather unusual circumstances as at Lake Decatur, the fish can be assigned to broods on the basis of scale patterns, fig. 10. No method has yet been discovered for determining in all cases whether marginal growth represents growth of the current season or of the previous season. While absorption at the edge of the white crappie scale (in summer collections) apparently indicates that the new year's growth has been delayed (Hansen 1937), the lack of absorption may not mean that growth of the current year has already started. Absorption seems to be of irregular and unpredictable occurrence. Summer, then, is not the most favorable time for collecting scales for age studies.

From the Lake Decatur collections it appears, in spite of many exceptions, that formation of one ring for each year of life is at least usual in white crappies. But the fact that many departures from a strictly annual rate were found, and the additional fact that the scale reader would not ordinarily be in position to detect those departures, tends to limit the confidence which can properly be placed in any single reading. Adding greatly to the difficulty of scale reading is the imprecise manner in which many of the rings are formed. Age determination in the white crappie is not

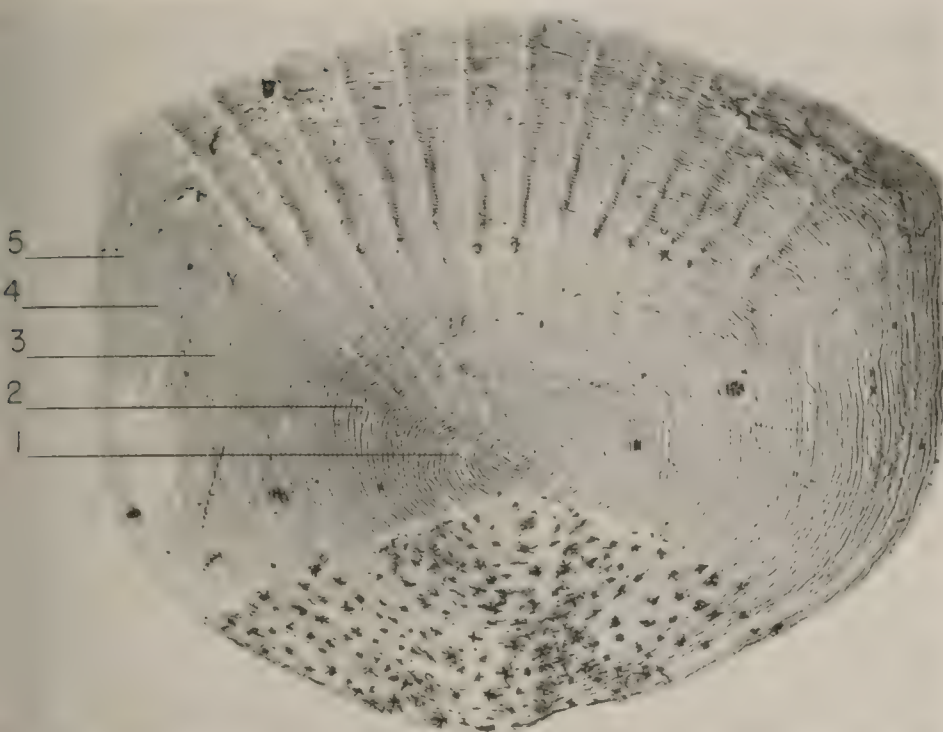


Fig. 9.—Scale from a white crappie that measured 10.1 inches when captured from the Rock River at Lyndon, Illinois, March 14, 1931. Cutting-over is unusually conspicuous in one of the lateral fields of annulus 3. The annulus or annual ring (five annuli are shown in the scale pictured) is a mark separating successive zones of annual growth. It makes its appearance on the scale when the fish begins a new season of growth rather than at the termination of a season of growth. The successive dark lines between the annuli represent ridges termed circuli. The distances between adjacent annuli are approximately proportional to growth increments of the fish in the years represented. The fish from which this scale was taken was not of known age, but its age is estimated to have been about $5\frac{3}{4}$ years. Its age was greater than that of most crappies taken from Illinois waters. Relatively few crappies live longer than 3 or 4 years.

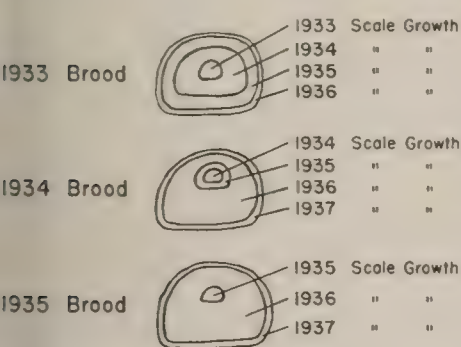


Fig. 10.—Annual ring patterns, that is, ring spacing, of white crappie broods hatched at Lake Decatur in the years 1933, 1934, and 1935. These ring patterns served to make individuals of the broods recognizable in later years.

a simple process of counting clearly defined marks of uniform appearance but instead is one which usually involves picking the true marks from an assortment which, to the scale reader, may seem to include some true rings, some false rings, and some rings which might be either one or the other.

Because of these several possible sources of error in aging white crappies through scale reading, the handling of the scale reading for the present paper needs explanation. Reading was carried on from the point of view that the scale method of aging fish should be used even though in many instances the age read might be only an approximation of the true age. However, it is believed that in only relatively

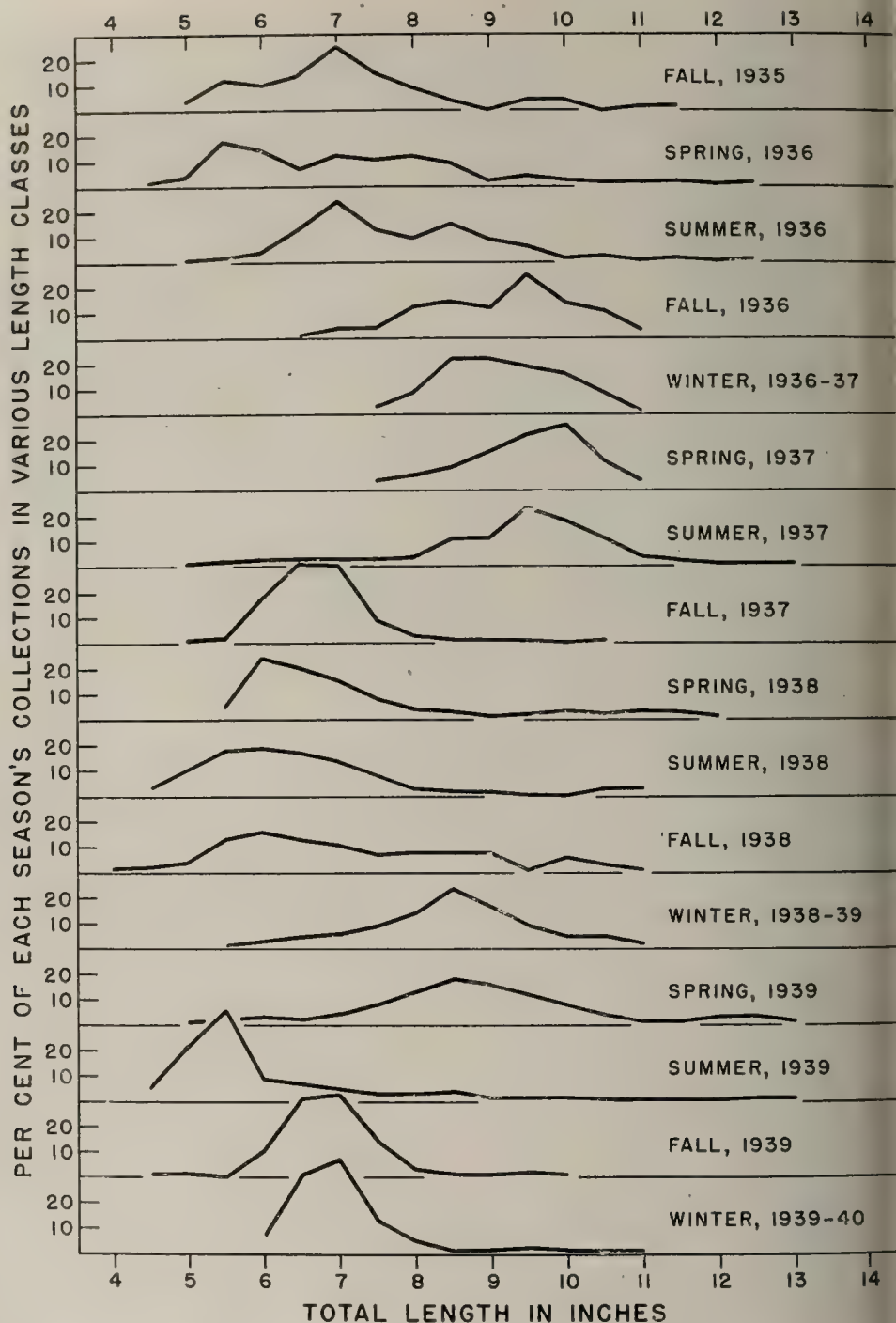


Fig. 11.—Length-frequency distribution (by half-inch classes) of Lake Decatur white crappies collected during the period 1935–1940. (Data from table 19. Some seasons omitted from graph because of meager data.)

few cases of age approximation did the age read deviate from the true age by more than a year.

Few scales were discarded for lack of their easy readability. If, on an individual scale, a ring was present that was believed to be false, the ring was omitted from the count. Conversely, a ring was sometimes counted, though imperfectly shown, or even entirely lacking, if supplementary information, such as length of fish, indicated that it should have been present. However, no addition was made to the count in the case of an unformed ring of the current year in a fish collected within the period of annulus formation.

The lack of a thoroughgoing study of age reading in crappies of positively known ages means that it is not yet possible to judge the success with which ages usually have been puzzled out or to appraise the effect of errors introduced either by faulty ring formation or faulty scale reading.

The Lake Decatur white crappie scales studied intensively for several years were

usually more easily understood and probably read with a greater degree of accuracy than the scales from other places in the state. Favoring accurate determinations in the Lake Decatur scales were wide fluctuations in annual growth, which produced ring spacing patterns that were generally diagnostic for the various broods. Fig. 10 shows these patterns in three broods. Two later broods were separated on a length basis.

Size and Age Distribution

The size distribution in net catches of white crappies at Lake Decatur changed considerably from year to year, table 19 and fig. 11. Catches in some years included many large crappies; in other years mostly small. Moderate to large sizes, 8 to 11 inches, were prevalent in the nets at two periods (in alternate years) during the 4 years of study: from the fall of 1936 to the summer of 1937 and from the fall of 1938 to the spring of 1939. Occasional

Table 19.—Length distribution of white crappies caught in hoop nets at Lake Decatur; collections are grouped according to 3-month periods—spring: March, April, May; summer: June, July, August; fall: September, October, November; and winter: December, January, February. The same data expressed as percentages are plotted in fig. 11.

TOTAL LENGTH, INCHES*	FALL, 1935	SPRING, 1936	SUMMER, 1936	FALL, 1936	WINTER, 1936-37	SPRING, 1937	SUMMER, 1937	FALL, 1937	WINTER, 1937-38	SPRING, 1938	SUMMER, 1938	FALL, 1938	WINTER, 1938-39	SPRING, 1939	SUMMER, 1939	FALL, 1939	WINTER, 1939-40
4.....	—	—	—	—	—	—	—	—	—	1	—	1	—	—	1	—	—
4½.....	—	3	—	2	—	—	—	—	1	—	3	—	—	1	33	3	1
5.....	2	17	1	1	—	—	6	2	—	1	12	3	—	6	135	2	1
5½.....	9	78	4	—	—	—	9	9	—	22	21	19	2	12	225	1	3
6.....	8	65	7	1	—	1	18	70	1	79	22	23	4	15	54	27	58
6½.....	11	29	25	2	—	2	17	125	7	67	20	18	8	13	43	83	260
7.....	18	53	47	12	1	2	16	121	4	51	16	15	9	21	33	90	298
7½.....	12	41	26	14	8	17	16	35	—	25	9	10	14	44	20	39	102
8.....	7	52	18	40	22	28	24	10	—	14	3	12	21	77	21	7	40
8½.....	3	40	30	45	66	40	58	3	—	8	2	11	37	106	24	3	11
9.....	—	10	17	39	66	70	57	4	—	3	2	11	26	93	7	3	11
9½.....	3	19	12	80	57	101	122	4	1	7	—	1	14	67	5	4	17
10.....	3	9	2	44	148	117	95	1	—	11	—	8	7	45	4	2	7
10½.....	—	4	4	36	22	55	59	3	—	7	3	4	8	25	1	1	4
11.....	1	3	—	9	4	17	21	—	2	9	3	2	3	7	1	—	4
11½.....	1	3	2	1	—	2	9	1	—	8	—	—	—	7	2	—	—
12.....	—	—	—	—	—	—	4	—	2	4	—	—	—	15	—	—	—
12½.....	—	2	2	—	—	1	4	—	—	—	—	—	—	16	6	1	—
13.....	—	—	—	—	—	1	4	—	—	—	—	—	—	7	4	—	—
13½.....	—	—	—	—	—	—	2	—	—	1	—	—	—	2	—	—	—
14.....	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Total	78	428	197	326	294	454	541	388	18	320	116	143	153	579	619	266	817

* Class center; for example, the 6-inch class includes fish of 5.8 through 6.2 inches in length.

observations of fishermen's stringers showed that nets were good indicators of the sizes likely to be caught by anglers.

Changes in Size Distribution.—Three separate factors enter into the changes in size distribution in the net samples: (1) availability in summer of broods hatched in the previous year; (2) summer growth of individual fish; and (3) periodic large-scale, and somewhat sudden, natural mortality of large fish, leaving for a time mainly fish of small sizes. The removal of large crappies by anglers is believed to have been a minor factor contributing to the periodic scarcity of large fish in the net samples.

Conspicuous changes in size distribution in white crappie populations were observed by Thompson & Bennett (1938) in an Illinois lake and by Wickliff *et al.* (1944, 1946) in several Ohio lakes. Size distribution changes in a black crappie population were observed by Thompson (1941). Thompson suggested that a single successful brood of black crappies hatched at Senachwine Lake in 1 year was able to consume most of the young crappies hatched for 3 or 4 years thereafter. When this first brood reached an age of 4 or 5 years, its members were sufficiently reduced by mortality that another brood survived in abundance. There is no evi-

Table 20.—Number of white crappies of various broods taken in hoop-net catches and number caught per net-day at Lake Decatur.

DATE OF COLLECTION ¹	HOOP-NET DAYS ²	1933 BROOD		1934 BROOD		1935 BROOD		1936 BROOD		1937 BROOD	
		Number	Number per Net-Day	Number	Number per Net-Day	Number	Number per Net-Day	Number	Number per Net-Day	Number	Number per Net-Day
<i>1936</i>											
April 3.....	16	152	9.7	168	10.5	—	—	—	—	—	—
May 4-6.....	4	18	4.5	44	11.0	—	—	—	—	—	—
May 29-June 4.....	7	59	8.3	24	3.4	—	—	—	—	—	—
July 3-5.....	6	5	8.3	36	6.0	—	—	—	—	—	—
July 31-Aug. 3.....	5	4	8.0	27	5.4	51	10.5	—	—	—	—
Sept. 8-14.....	6	2	0.3	11	1.8	14	2.3	—	—	—	—
Sept. 22.....	4	1	0.2	11	2.7	49	12.2	—	—	—	—
Oct. 24-27.....	12	17	1.4	139	11.6	69	5.7	—	—	—	—
Dec. 21.....	15	18	1.2	107	7.1	171	11.4	—	—	—	—
<i>1937</i>											
March 1-4.....	16	53	3.3	220	13.7	67	4.2	—	—	—	—
April 24.....	6	14	2.3	67	11.2	35	5.8	—	—	—	—
June 3-5.....	12	32	2.7	116	9.7	62	5.2	—	—	—	—
June 24.....	9	27	3.0	73	8.1	27	3.0	—	—	—	—
July 10-16.....	27	15	0.6	37	1.4	29	1.1	6	0.2	—	—
Aug. 6-14.....	30	2	0.1	8	0.3	13	0.4	45	1.5	—	—
Sept. 22.....	6	2	0.3	2	0.3	7	1.2	206	34.3	—	—
Nov. 3.....	6	0	—	2	0.3	3	0.5	165	27.5	—	—
<i>1938</i>											
Jan. 17-24.....	17	0	—	3	0.2	0	0.0	12	0.7	—	—
March 14.....	9	0	—	14	1.0	16	1.8	181	20.1	—	—
May 28.....	8	0	—	8	1.0	4	0.5	84	10.5	—	—
July 1-14.....	9	0	—	0	—	4	0.4	24	2.7	—	—
Aug. 25.....	14	0	—	0	—	2	0.1	19	1.4	56	4.0
Oct. 6.....	10	0	—	0	—	0	—	9	0.9	59	5.9
Nov. 4-11.....	20	0	—	0	—	0	—	17	0.9	49	2.5
<i>1939</i>											
Jan. 9.....	12	0	—	0	—	0	—	71	5.9	77	6.4

¹ June 22, 1936, data omitted because of uncertainties in age determination.

² The number of hoop-net days was obtained by multiplying the number of nets by the number of (24-hour) days they were fished.

dence that one brood dominated later broods in this manner at Lake Decatur, where strong broods were produced each year.

Changes in Age Distribution.—The entry of young broods into the net samples and the dropping out of older ones at Lake Decatur is shown somewhat roughly in table 20 by changes in the rate of catch in nets. The relatively short life span of broods was an outstanding characteristic of the Lake Decatur white crappie population. Assuming that June 1 was the approximate hatching date for all broods, it may be determined from table 20 that the 1933 brood disappeared from the net samples at an age of about 4 years and 4 months, the 1934 brood at 4 years, and the 1935 brood at 3 years and 3 months. But each of these broods showed a major decline in numbers a full year preceding its final disappearance from the samples, table 20. Longer life spans were observed in some broods in Lake Decatur, table 24, and in a number of other localities, table 28. It may be noticed, however, that fish with more than three annual rings were frequently scarce in Illinois collections. The highest number of annual rings, observed among several thousand age readings, was eight, table 28.

Influence of Periodic High Mortality on Size and Age Distribution.—The sharp drop in summer netting rates, table 20, suggests that heavy mortality occurred at Lake Decatur in one or more broods during the summer months in 1936, 1937, and 1938. Most broods, however, showed a certain amount of recovery in rate of nettability from summer to winter, indicating that the depressed summer rates were, in part, the result of low efficiency of summer netting operations. There is no clear indication of high summer mortality in these broods during their second summer of life—the first summer of net capture.

Lack of age readings prevented inclusion of most of the 1939 catch figures in table 20. However, there is evidence of considerable summer mortality among large crappies in 1939 from the fact that fish of the larger sizes were relatively more abundant in the spring than in the other seasons of that year, table 19 and fig. 11.

Normal variations in net catches make it impossible to give the exact date of highest summer mortality. It is suspected that highest losses may have occurred in June or July when the older crappies were at the lowest point in the annual condition cycle, although inquiries among lake-shore residents failed to show that dead crappies were more abundant along shore in June or July than at other times of the year.

Annual Growth Period

The beginning of the annual growth period of white crappies is marked by formation of the annual ring or annulus, fig. 9. Data on the time of annulus formation in white crappies at Lake Decatur in 1935 and 1936 have been published (Hansen 1937). Data for 1937 and 1938 are given in tables 21 and 22. A summary of data for the 4 years is given in table 23. The method of determining the time of annulus formation in crappies of 1937 and 1938 collections was more precise than the method used with the 1935 and 1936 collections. Because of the distinctive ring patterns of most broods of Lake Decatur white crappies in 1937 and 1938 collections, fig. 10, individual fish were assigned to their respective broods. Scales were then examined for presence or absence of annuli of the current growing season and for marginal growth beyond the new annuli.

On the basis of these studies, it is apparent that some white crappies of Lake Decatur started their annual growth much earlier than others, as much as 6 weeks earlier in one season to 10 weeks earlier in another. Generally, small, sexually immature fish formed their annuli earlier than large, mature ones.

The end of the annual growth period is estimated from the data on average length of fish in the various age classes in successive summer, fall, and early winter collections, table 24. Judged by length observations in well-represented age classes—classes with one or two annual rings—the fish of most Lake Decatur broods stopped growing about the latter part of September. However, there is indication that members of some broods may have continued to grow, but at a very slow

rate, during the months of October and November.

For two reasons it is not possible to state with certainty when growth stopped

completely. First, there were gaps of a month or more between collections. Second, the length averages calculated for some broods tended to be erratic; for in-

Table 21.—Data on annulus formation in white crappies at Lake Decatur in 1937.

DATE OF COLLECTION	1935 BROOD			1934 BROOD			1933 BROOD		
	Total Number Caught	Number Having the 1937 Annulus	Per Cent Having the 1937 Annulus	Total Number Caught	Number Having the 1937 Annulus	Per Cent Having the 1937 Annulus	Total Number Caught	Number Having the 1937 Annulus	Per Cent Having the 1937 Annulus
March 1-4....	67	0	0.0	220	0	0.0	54	0	0.0
April 24.....	34	0	0.0	67	0	0.0	14	0	0.0
May 16.....	37	0	0.0	39	0	0.0	10	0	0.0
June 3-5.....	71	8	11.5	117	0	0.0	36	0	0.0
June 24.....	27	3	11.1	74	1	1.3	26	0	0.0
July 10-16....	30	12	40.0	37	1	2.7	15	0	0.0
Aug. 6-14....	15	15	100.0	9	8	89.0	1	1	100.0
Sept. 22.....	5	5*	100.0	2	2*	100.0	—	—	—
Nov. 3.....	2	2*	100.0	2	2	100.0	—	—	—

* One of these fish showed an incomplete stage of annulus formation where new circuli were present on some of the scales but not others, or where new circuli were present only in certain areas of some scales.

Table 22.—Data on annulus formation in white crappies at Lake Decatur in 1938.

DATE OF COLLECTION	1936 BROOD			1935 BROOD			1934 BROOD		
	Total Number Caught	Number Having the 1938 Annulus	Per Cent Having the 1938 Annulus	Total Number Caught	Number Having the 1938 Annulus	Per Cent Having the 1938 Annulus	Total Number Caught	Number Having the 1938 Annulus	Per Cent Having the 1938 Annulus
March 14.....	—	—	—	12	0	0.0	13	0	0.0
May 28.....	69	0	0.0	5	0	0.0	5	0	0.0
July 1.....	4	2	50.0	2	0	0.0	2	0	0.0
July 14.....	24	6	25.0	—	—	—	1	0	0.0
Aug. 25.....	18	18*	100.0	2	1	50.0	1	1	100.0
Oct. 6.....	—	—	—	2	2	100.0	—	—	—
Nov. 4-11....	—	—	—	4	4	100.0	1	1	100.0

* One of these fish had the annulus on only a part of its scales; of those scales which did not have the annulus some showed absorption and some did not.

Table 23.—Approximate periods of annulus formation in white crappies at Lake Decatur 1935-1938.

YEAR OF OBSERVATION	APPROXIMATE DATES OF ANNULUS FORMATION*	APPROXIMATE LENGTH OF PERIOD
1935.....	Early May to early July or later.....	2 months or longer
1936.....	Early May to early July.....	1½ to 2 months
1937.....	Mid-May to early August or later.....	2½ months or longer
1938.....	Early June to late August or later.....	2½ months or longer

* The term "or later" is added when some individuals had still not formed the annulus at the approximate end of the period.

ANNUAL RING CLASS

NUMBER
OF FISH

DATE OF COLLECTION

	0	1	2	3	4	5	6
1935							
Nov. 22.....		6.5 (47)	7.9 (29)	11.4 (2)	—	—	—
1936							
April 3.....	—	6.0 (165)	7.9 (152)	10.2 (3)	10.4 (2)	9.8 (2)	—
May 4.....	—	6.1 (44)	8.1 (27)	11.5 (2)	12.4 (1)	11.7 (1)	—
May 29 June 4.....	—	6.9 (14)	8.1 (76)	10.9 (6)	12.0 (1)	11.7 (3)	—
July 3.....	—	6.8 (3)	7.7 (37)	8.1 (5)	—	—	—
July 31-Aug. 3.....	—	6.6 (51)	8.4 (19)	8.8 (3)	—	—	—
Sept. 22.....	—	8.1 (49)	9.3 (11)	9.6 (1)	—	—	—
Oct. 24-27.....	—	8.6 (71)	9.8 (149)	10.1 (17)	—	—	—
Dec. 21.....	4.5 (1)	8.7 (170)	9.9 (107)	9.9 (18)	9.8 (1)	—	—
1937							
March 1-4.....	—	8.6 (67)	9.6 (220)	9.9 (54)	10.7 (2)	12.8 (2)	11.7 (1)
April 24.....	—	8.6 (36)	9.8 (67)	10.1 (14)	—	—	—
May 16.....	—	8.9 (37)	10.0 (39)	10.0 (10)	—	—	—
June 3-5.....	—	8.4 (63)	9.6 (125)	19.3 (37)	11.7 (4)	12.0 (3)	11.5 (1)
June 24.....	—	8.2 (28)	9.6 (76)	10.5 (27)	12.1 (3)	12.7 (5)	11.7 (1)
July 10-16.....	—	7.6 (25)	9.5 (48)	9.8 (16)	12.1 (4)	—	12.1 (1)
Aug. 6-14.....	—	6.4 (47)	8.7 (17)	10.2 (8)	10.4 (2)	—	—
Sept. 22.....	—	6.8 (207)	8.7 (7)	9.0 (2)	10.4 (2)	—	—
Nov. 3.....	—	6.5 (165)	9.2 (3)	10.3 (2)	—	—	—
1938							
Jan. 17-24.....	4.3 (1)	6.6 (12)	—	11.5 (3)	10.8 (2)	—	—
March 14.....	4.3 (2)	6.8 (179)	9.9 (16)	10.3 (14)	—	14.0 (1)	—
May 28.....	—	6.3 (86)	9.4 (5)	11.0 (12)	11.4 (4)	—	13.4 (1)
July 1.....	—	5.8 (2)	9.3 (6)	—	—	—	—
July 14 ³	—	5.7 (22)	6.0 (6)	11.1 (1)	—	—	—
Aug. 25.....	—	6.0 (58)	7.6 (19)	10.7 (2)	—	—	—
Oct. 6.....	—	7.5 (57)	8.9 (9)	10.3 (1)	—	—	—
Nov. 4-11.....	3.8 (1)	7.7 (44)	9.5 (10)	10.9 (2)	10.1 (1)	12.2 (1)	—
1939							
Jan. 9.....	4.1 (5)	7.7 (77)	9.0 (71)	10.5 (2)	10.9 (3)	—	13.0 (1)

¹ Only the largest representative of the group were caught in 1-inch mesh nets.² Caught by anglers.³ About six more large crappies, 10 to 11 inches long, were discarded without being measured or scales being taken.

second. Collections made during the period of summer formation may include individuals with a like number of visible rings). Figures in parentheses represent number of specimens.

stance, in 1937 collections, table 24, fish with one scale ring showed greater average length in September than in November.

Taking into account known individual differences in the beginning of the growing period and the uncertainties as to the end of the period, and ignoring any small growth which may have occurred in November, it may be estimated that the longest period of growth of any individual in any year was between 5 and 6 months, May 1 to September 30 or May 1 to October 31. It is almost certain, however, that in some years no individual grew for more than 4 months, that is, from June 1 to September 30. Since small, immature fish began growing earlier in the year than the spawners, the small fish probably grew for a longer period than the large fish.

The period of growth obviously was much less than 4 months for those white crappies that formed their annuli between the middle of July and the latter part of August. In 1937 the majority of individuals began their growth some time between the collecting dates of July 10 and August 14, and in 1938 between July 14 and August 25. The total growth period

for these fish could not have been longer than 2 or 3 months. In 1935 and again in 1937 occasional individuals did not grow at all, and it is conceivable that some others may have started to grow as late as September or October and may have grown for less than a month.

Crappies of the 1934 brood seined from a Sangamon River overflow during the high water of 1935 had made little progress on their second year's growth when they were taken in June and early July, table 27.

Jones (1941) observed that largemouth and smallmouth bass in Norris Reservoir, Tennessee, grew for 4 months in 1939. In the same locality in 1940, Eschmeyer & Jones (1941) found that black crappies grew for about 5 months and that largemouth, smallmouth, and Kentucky bass grew for about 5 or 6 months. These writers did not record that individuals began growth at widely different times.

Growth Rates

White crappie growth rates were found to vary in different waters of the state.

Table 25.—Average observed total lengths, in inches, of Lake Decatur white crappies of various ring classes at time of hoop-net capture between growing seasons. Data from table 24. Figures in parentheses represent numbers of specimens.

DATE OF COLLECTION	ANNUAL RING CLASS					
	1	2	3	4	5	6
Nov. 22, 1935.....	6.5 (47)	7.9 (29)	11.4 (2)	—	—	—
April 3, 1936.....	6.0 (165)	7.9 (152)	10.2 (3)	10.4 (2)	9.8 (2)	—
<i>Average</i>	6.1 (212)	7.9 (181)	10.7 (5)	10.4 (2)	9.8 (2)	—
Dec. 21, 1936.....	8.7 (170)	9.9 (107)	9.9 (18)	9.8 (1)	—	—
March 1-4, 1937.....	8.6 (67)	9.6 (220)	9.9 (54)	10.7 (2)	12.8 (2)	11.7 (1)
April 24, 1937.....	8.6 (36)	9.8 (67)	10.1 (14)	—	—	—
<i>Average</i>	8.7 (273)	9.7 (394)	9.9 (86)	10.4 (3)	12.8 (2)	11.7 (1)
Nov. 3, 1937.....	6.5 (165)	9.2 (3)	10.3 (2)	—	—	—
Jan. 17-24, 1938.....	6.6 (12)	—	11.5 (3)	10.8 (2)	—	—
March 14, 1938.....	6.8 (179)	9.9 (16)	10.3 (14)	—	14.0 (1)	—
<i>Average</i>	6.7 (356)	9.8 (19)	10.5 (19)	10.8 (2)	14.0 (1)	—
Nov. 4-11, 1938.....	7.7 (44)	9.5 (10)	10.9 (2)	10.1 (1)	12.2 (1)	—
Jan. 9, 1939.....	7.7 (77)	9.0 (71)	10.5 (2)	10.9 (3)	—	13.0 (1)
<i>Average</i>	7.7 (121)	9.1 (81)	10.7 (4)	10.7 (4)	12.2 (1)	13.0 (1)
<i>Grand average</i>	7.3	9.1	10.5	10.6	12.2	12.3

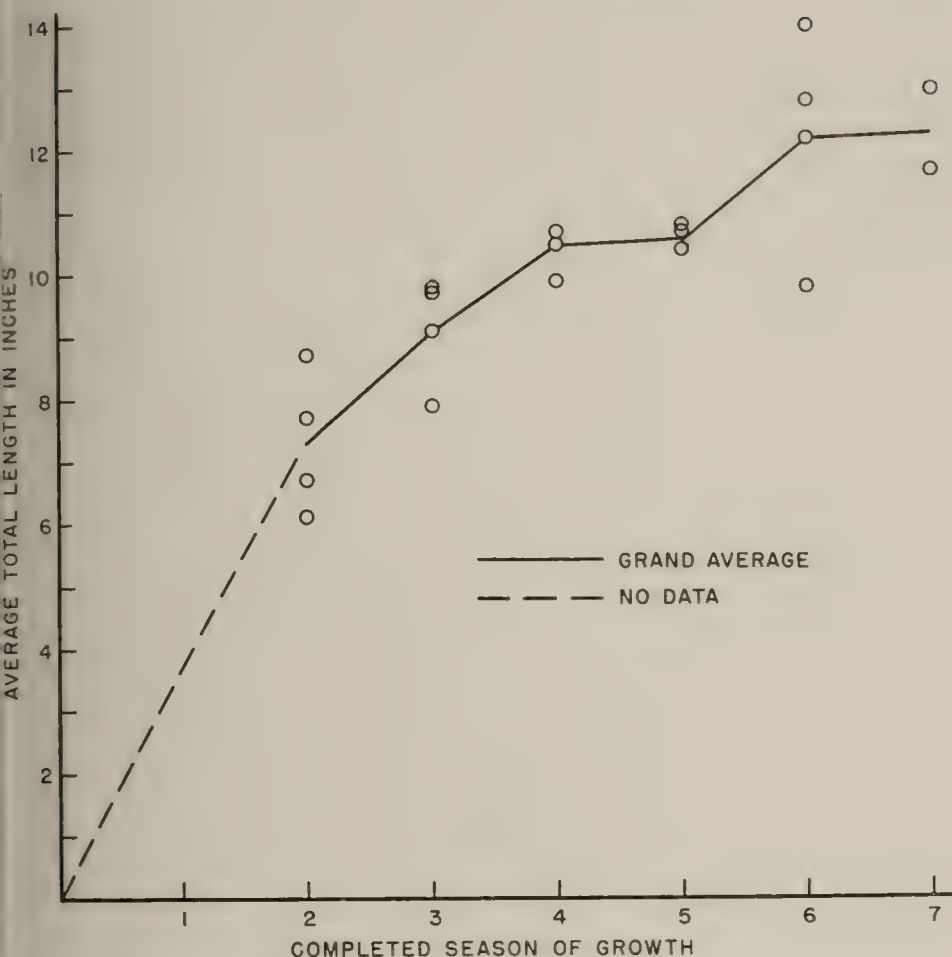


Fig. 12.—Observed average total lengths of Lake Decatur white crappies at end of various completed growing seasons. Each circle shows the average length of individuals of the same age found in winter collections of different calendar years. Sizes of crappies at end of first growing season are not shown, as fish were then too small to be taken in nets.

and from year to year in the same water—notably in Lake Decatur.

Growth Rates at Lake Decatur.—At the time of this study the average growth rate of the white crappies of Lake Decatur, as shown at the bottom of table 25, was probably equal to, if not faster than, the average rate for this species in other waters of the state, table 28.

The tendency toward rapid growth of the Lake Decatur white crappies means that, even though fish of large sizes were periodically almost wiped out by high mortality, rapid growth of the surviving younger fish resulted in a new supply of

large fish within about a year of the time when scarcity of large fish set in.

Growth of fish in the second and third years of life varied from good to poor, but poor growth was not seen in any one brood for 2 years in succession, and in all broods fish reached an average length of about 8 inches or more within their first three growing seasons.

Average sizes of Lake Decatur white crappies of six annual ring classes are shown in table 25 and fig. 12. Fish were placed in a given annual ring class in accordance with the scale reading practices described in the section "Age Determina-

Table 26.—Average observed total lengths, in inches, of Lake Decatur white crappie males and females. Figures in parentheses represent numbers of specimens.

DATE OF COLLECTION	ANNUAL RING CLASS									
	1		2		3		4		5	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
<i>1936</i>										
July 31-Aug. 3.	6.6 (27)	6.5 (24)	8.4 (14)	8.4 (13)	8.8 (2)	9.2 (2)	—	—	—	—
Sept. 8-22.....	8.1 (37)	7.7 (25)	9.2 (14)	9.4 (9)	9.6 (1)	9.5 (2)	—	—	—	—
Oct. 24-27.....	8.6 (42)	8.6 (25)	9.9 (70)	9.8 (74)	9.2 (7)	10.8 (10)	—	—	—	—
Dec. 21.....	8.7 (96)	8.7 (76)	9.8 (51)	9.9 (54)	9.4 (6)	10.0 (12)	—	—	—	—
<i>1937</i>										
March 1-4.....	8.6 (34)	8.4 (18)	9.6 (96)	9.8 (98)	9.8 (19)	10.1 (28)	9.8 (1)	11.3 (1)	—	11.7 (1)
April 24.....	8.8 (15)	8.7 (19)	9.6 (22)	9.8 (45)	10.4 (4)	10.1 (10)	—	—	—	—
June 3-5.....	8.6 (34)	8.6 (25)	9.6 (45)	9.4 (44)	10.1 (10)	10.4 (25)	—	11.7 (4)	11.5 (1)	—
June 24.....	8.8 (16)	8.6 (8)	9.5 (30)	9.8 (45)	10.4 (6)	10.5 (19)	—	12.1 (3)	—	11.7 (1)
<i>1938</i>										
Nov. 4-11.....	7.8 (27)	7.6 (22)	9.8 (5)	9.2 (12)	10.4 (3)	10.8 (1)	10.1 (1)	—	12.2 (1)	9.2 (1)
<i>1939</i>										
Jan. 9.....	7.8 (51)	7.5 (26)	9.3 (33)	8.9 (38)	10.8 (1)	10.3 (1)	10.8 (2)	11.3 (1)	—	—
<i>Average</i>	8.3 (379)	8.2 (268)	9.6 (380)	9.6 (432)	9.9 (59)	10.3 (110)	10.4 (4)	11.7 (9)	12.2 (1)	12.0 (10)
									11.5 (1)	11.7 (2)

Table 27.—Average size of white crappies after approximately one season of growth, based on direct observation of young fish. In the estimation of age it was assumed that the fish were spawned about June 1.

BODY OF WATER	DATE OF OBSERVATION	NUMBER OF SPECIMENS	APPROXIMATE AGE, MONTHS	AVERAGE TOTAL LENGTH, INCHES
Buck's Pond, Monticello.....	Oct. 6, 1938.....	115	4	2.6
Ortman's Lake, Crescent City....	Oct. 19, 1933.....	37	4½	3.7
Lincoln Lakes, Lincoln.....	May 20, 1938.....	17	12	3.7
Sangamon River overflow below Lake Decatur Dam.....	May 20-22, 1935	61	12	3.5
	June 26, 1935*	50	13	3.6
	July 11-16, 1935..	96	13½	3.7

*The fish in this collection and the one following were a little more than a year old but making slow second-summer growth.

tion." For example, all fish having scales that the reader interpreted as having one ring were placed in annual ring class 1. The fish of that category represented in this table were believed to have completed two seasons of growth.

The data in table 25 were taken from table 24 and include only fish caught from early November to late April, a time of year when the fish were not growing in length (except perhaps at a very slow rate) and annual rings were not being formed.

Comparisons of the year-to-year growth of the Lake Decatur white crappies of various broods can be made by reading the boldface type in table 25 diagonally downward from left to right. For example, fish of the 1934 brood showed one scale ring and averaged 6.1 inches in the combined collections of November 22, 1935, and April 3, 1936. It is this same brood that showed two rings and averaged 9.7 inches a year later in the combined collections of December 21, 1936, March 1-4, and April 24, 1937.

Comparisons of the average lengths of the fish of different broods at the same attained ages can be made by reading the boldface type in table 25 vertically.

The year 1936 was an exceptionally good growing year at Lake Decatur, particularly for fish in the second and third years of life. The good growth of the 1934 brood in 1936 is shown in the figures cited above. Fish of the 1935 brood averaged 3.5 inches at the start of the 1936 growing season and reached a length of 8.7 inches at the end. (The length at the start of the season was computed from scale measure-

ments; similar computation was not employed elsewhere in this paper.) The exceptionally good growth made by these broods in 1936 is believed to have resulted from heavy feeding on fingerling gizzard shad, *Dorosoma*, which were commonly seen in schools and were regularly found in crappie stomachs during the 1936 growing season. The very good growing season of 1936 came between two very poor growing seasons, 1935 and 1937.

In studies on other centrarchids by Hile (1931), Tester (1932), Hubbs & Cooper (1935), Bennett (1938), Schoffman (1938, 1939), and Bennett, Thompson, & Parr (1940), males and females showed very nearly the same rates of growth, or the males showed a tendency to grow slightly faster than the females. At Lake Decatur, among white crappies that were sexed, table 26, there were only small differences in average lengths of males and females of the same age, and such differences, seldom amounting to more than one-half inch, were not consistently in favor of either sex in the various collections.

Growth Rates in Other Illinois Waters.—Because white crappies are seldom caught in 1-inch-mesh hoop nets until they are 13 to 15 months old, the average size reached by these fish at the end of their first season has been determined by direct observation of young fish captured in four Illinois waters by means other than hoop nets, table 27. The Lincoln Lakes and Buck's Pond samples were taken by poisoning, the Ortman's Lake sample by draining, and the Sangamon River back-water samples by seining.

Table 28.—Average observed total lengths, in inches, of white crappies from various Illinois waters, the fish grouped according to annual ring classes. Figures in parentheses represent numbers of specimens. (Lake Decatur hoop-net collections, 1935-1939, shown in table 24).

BODY OF WATER AND NEAREST TOWN	DATE	METHOD OF COLLECTION ¹	NUMBER OF SPECI- MENS	ANNUAL RING CLASS							
				1	2	3	4	5	6	7	8
<i>Illinois River and Oxbow Lakes</i>											
Senachwine Lake, Henry	Aug. 18-31, 1933	1 inch H	70	6.3 (54)	7.3 (14)	8.1 (2)	—	—	—	—	—
	Sept. 1-29, 1933	1 inch H	115	6.5 (86)	8.7 (23)	8.9 (6)	—	—	—	—	—
	Oct. 2-13, 1933	1 inch H	80	6.5 (42)	8.3 (38)	—	—	—	—	—	—
	June 8-20, 1934	1 inch H	66	5.2 (15)	7.2 (49)	7.9 (2)	—	—	—	—	—
	Dec. 6-17, 1931	1 inch H & S	26 ²	7.5 (9)	8.7 (12)	9.0 (4)	9.8 (1)	—	—	—	—
Clear Lake, Liverpool	Sept. 1-9, 1936	1 inch H	196	6.9 (148)	6.9 (48)	—	—	—	—	—	—
Lake Chautauqua, Havana	Nov. 13-14, 1936	1 inch H	78	7.9 (76)	8.2 (2)	—	—	—	—	—	—
	Jan. 3, 1931	?	23 ³	—	7.8 (10)	8.1 (10)	8.2 (2)	7.5 (1)	—	—	—
	May 11, 1931	1 1/4 inch S	18 ³	6.5 (4)	7.0 (8)	7.1 (6)	—	—	—	—	—
	June 9, 1931	1/4 inch S	32 ³	5.3 (13)	6.0 (13)	6.5 (6)	—	—	—	—	—
Matanzas Lake, Havana	Feb. 16-March 4, 1931	1 1/2 inch H	141 ³	6.8 (16)	8.6 (32)	9.3 (85)	9.5 (8)	—	—	—	—
	Jan. 24, 1931	1 1/2 inch H	15 ³	—	9.0 (4)	9.5 (10)	9.6 (1)	—	—	—	—
	Nov. 4-19, 1931	1 inch H	143 ³	8.4 (80)	9.6 (46)	10.0 (15)	10.8 (2)	—	—	—	—
Stewart Lake, Browning	Nov. 5, 1931	1 inch H	15 ³	9.2 (7)	9.8 (7)	11.0 (1)	—	—	—	—	—
Meredosia Bay, Meredosia	June 21-29, 1927	1 1/4-1 1/2 inch H	15	—	9.3 (9)	10.8 (6)	—	—	—	—	—
	June 23-29, 1931	1 inch H	79	5.7 (10)	6.9 (30)	9.2 (15)	9.3 (19)	9.3 (5)	—	—	—
	July 11-31, 1931	1 inch H	230	6.1 (21)	7.3 (20)	9.0 (44)	9.6 (122)	9.5 (22)	11.3 (1)	—	—
	Aug. 5-7, 1931	1 inch H	50	7.1 (1)	8.3 (8)	8.9 (23)	9.4 (15)	9.5 (3)	—	—	—
	May 18-29, 1934	1 inch H	46	7.8 (19)	9.2 (12)	10.3 (10)	11.3 (2)	11.1 (3)	—	—	—
<i>Mississippi River and Oxbow Lakes</i>											
River channel, Savanna	Sept. 1-7, 1932	1 inch S	27	—	7.6 (8)	7.8 (9)	8.3 (7)	8.7 (2)	8.9 (1)	—	—
River channel, Clinton, Iowa	Sept. 14-20, 1932	1 inch H	33	—	7.8 (22)	8.1 (9)	9.5 (1)	8.9 (1)	—	—	—
River channel, New Boston	Aug. 14-19, 1932	1 inch H & S	39	—	7.9 (9)	7.7 (14)	8.3 (9)	8.7 (5)	9.2 (1)	7.9 (1)	—
Horseshoe Lake, Cairo	March 16-24, 1936	1 inch H	52	7.0 (4)	9.6 (7)	11.3 (36)	14.6 (4)	13.1 (1)	—	—	—
	April 8, 1937	1 inch H	94	7.5 (39)	9.0 (2)	12.1 (10)	13.6 (38)	13.1 (3)	13.3 (1)	13.1 (1)	—
	Feb. 19-27, 1938	1 inch H	178	7.1 (81)	8.7 (71)	12.6 (3)	12.1 (8)	13.9 (15)	—	—	—
	May 7, 1938	1 inch H	47	7.2 (17)	8.2 (20)	8.7 (1)	13.3 (2)	14.1 (5)	14.2 (1)	14.9 (1)	—
	April 19, 1941	2 1/2 inch H	33 ²	—	—	12.9 (2)	12.8 (9)	14.1 (17)	13.1 (1)	15.9 (3)	15.5 (1)
<i>Fox River</i>											
River channel, 1-3 mi. above Grass Lake, Spring Grove	July 10-14, 1930	1 1/2 inch H	17	—	—	8.3 (6)	9.3 (9)	10.3 (2)	—	—	—
River channel, McHenry	July 16-Aug. 1, 1930	1 inch H & S	45	5.1 (3)	7.0 (14)	8.8 (21)	9.8 (6)	8.9 (1)	—	—	—
River channel, above St. Charles dam	Aug. 21, 1930	1 inch H & S	22	5.8 (7)	7.8 (14)	9.8 (3)	10.5 (7)	—	—	—	—

Sterling pool, Nelson.....	Nov. 6, 1934	10	—	8 7 (4)	10 8 (4)	11 5 (2)	—
Sterling pool, Sterling.....	April 21, 1938	13	7 9 (9)	8 9 (3)	9 5 (1)	—	—
<i>Kaskaskia River</i>							
River channel, Sullivan to Carlyle.....	Aug. 1 23, 1929	55	6 3 (1)	7 1 (34)	8 1 (16)	7 9 (4)	—
<i>Ohio River and Oxbow Lakes</i>							
River channel, Shawneetown.....	May 1 21, 1935	197	5 4 (2)	7 0 (84)	7 5 (101)	9 0 (10)	—
Allard Lake, Brookport	March 29-April 4, 1930	68 ³	—	8 6 (39)	9 3 (23)	9 9 (6)	—
Kinman Lake, Brookport.....	April 12 18, 1930	64	—	8 7 (11)	9 8 (28)	11 9 (13)	11 8 (2)
<i>Lower Saline River and tributaries</i>							
Shawneetown	June 5 12, 1935	18	6 9 (1)	8 2 (6)	9 0 (7)	9 9 (3)	11 4 (1)
<i>Sangamon River</i>							
River channel, Mahomet.....	June 11-24, 1933	33	6 3 (15)	6 8 (15)	6 9 (3)	—	—
	July 7-24, 1933	66	6 3 (18)	6 4 (34)	7 0 (14)	—	—
	Aug. 2-18, 1933	35	6 0 (16)	6 5 (18)	7 3 (1)	—	—
	Sept. 7-21, 1933	48	6 0 (16)	6 5 (31)	7 6 (1)	—	—
River channel, Monticello	July 12 13, 1929	19	—	6 6 (13)	6 0 (5)	8 6 (1)	—
River channel, Decatur.....	May 17, 1935	33	7 9 (23)	7 7 (7)	9 4 (3)	—	—
	June 25-26, 1935	108	6 4 (49)	6 9 (51)	7 0 (4)	9 3 (2)	8 1 (2)
	July 11-16, 1935	192	6 8 (77)	7 0 (104)	9 4 (9)	8 4 (2)	—
<i>Miscellaneous Lakes</i>							
Maple Lake, Willow Springs	Aug. 10-31, 1937	84	6 6 (7)	7 8 (64)	8 7 (11)	8 8 (2)	—
Lake Bloomington, Bloomington.....	Sept. 10, 1937	49	6 4 (17)	7 1 (15)	7 5 (17)	—	—
Lincoln Lake, Lincoln.....	June 15, 1937	34	5 5 (1)	6 9 (5)	6 5 (27)	9 5 (1)	—
	May 20, 1938	146	5 6 (45)	6 3 (58)	6 6 (3)	7 0 (40)	—
Weldon Springs Lake, Weldon.....	July 7, 1936	28	—	7 2 (4)	7 6 (20)	8 4 (4)	—
	Sept. 6, 1938	115	5 4 (49)	6 1 (64)	6 1 (1)	—	12 8 (1)
Homewood Lake, Decatur.....	April 12, 1938	88	6 3 (33)	7 1 (28)	7 2 (23)	7 3 (3)	6 8 (1)
	June 16-29, 1938	87	5 7 (8)	6 4 (52)	7 1 (21)	6 9 (6)	—
	July 21, 1938	47	—	6 4 (36)	6 9 (9)	7 3 (2)	—
Mattoon Lake, Mattoon	March 12 14, 1931	181	6 5 (3)	8 4 (5)	8 7 (6)	9 6 (2)	15 4 (1)
Pollywogs, Danville	Feb. 28, 1931	12	—	9 9 (7)	9 6 (2)	8 9 (1)	11 0 (1)
	Dec. 26, 1931-						
	April 9, 1932	30 ²	9 5 (1)	9 4 (27)	10 3 (2)	—	—

¹ Method of collection: A—Angling; H—hoop net; S—seine; P—introduced pump (ten feet); H S—hoop net and seine; H A—hoop net and unsifted seines; I—unsifted devices. Mesh sizes refer to bar or square measure in inches. The mesh size of a hoop net is given only for the pot of the net.

² Extent of selectivity not known.
³ Not a random sample. In most of these selective samples, scales were not taken from individuals under about 6 inches total length.
⁴ Probably not a random sample, but all sizes represented to some extent.

Table 29.—Selected examples of rapid growth and slow growth in Illinois white crappies. Observed total lengths in inches. (Data from tables 24 and 28.) Figures in parentheses represent numbers of specimens.

BODY OF WATER AND NEAREST TOWN	DATE OF COLLECTION	ANNUAL RING CLASS						
		1	2	3	4	5	6	7
<i>(Populations Exhibiting Rapid Growth)</i>								
Horseshoe Lake, Cairo.....	April 8, 1937.....	7.5 (39)	9.0 (2)	12.1 (10)	13.6 (38)	13.1 (3)	13.3 (1)	13.1 (1)
Lake Decatur, Decatur.....	March 14, 1938.....	6.8 (179)	9.9 (16)	10.3 (14)	—	14.0 (1)	—	—
Kinneman Lake, Brookport.....	April 12-18, 1930.....	—	8.7 (11)	9.8 (28)	11.9 (13)	11.8 (10)	11.8 (2)	—
Meredosia Bay, Meredosia.....	May 18-29, 1934.....	7.8 (19)	9.2 (12)	10.3 (10)	11.3 (2)	11.1 (3)	—	—
Illinois River channel, Bath.....	Nov. 4-19, 1931.....	8.4 (80)	9.6 (46)	10.0 (15)	10.8 (2)	—	—	—
<i>(Populations Exhibiting Slow Growth)</i>								
Weldon Springs Lake, Weldon.....	Sept. 6, 1938.....	5.4 (49)	6.1 (64)	6.1 (1)	—	—	12.8 (1)	—
Lincoln Lakes, Lincoln.....	May 20, 1938.....	5.6 (45)	6.3 (58)	6.6 (3)	7.0 (40)	—	—	—
Homewood Lake, Decatur.....	April 12, 1938.....	6.3 (33)	7.1 (28)	7.2 (23)	7.3 (3)	6.8 (1)	—	—
Ohio River, Shawneetown.....	May 1-21, 1935.....	5.4 (2)	7.0 (84)	7.5 (101)	9.0 (10)	—	—	—
Sangamon River, Mahomet.....	Sept. 7-21, 1933.....	6.0 (16)	6.5 (31)	7.6 (1)	—	—	—	—
Kaskaskia River, Sullivan to Carlyle.....	Aug. 1-23, 1929.....	6.3 (1)	7.1 (34)	8.1 (16)	7.9 (4)	—	—	—

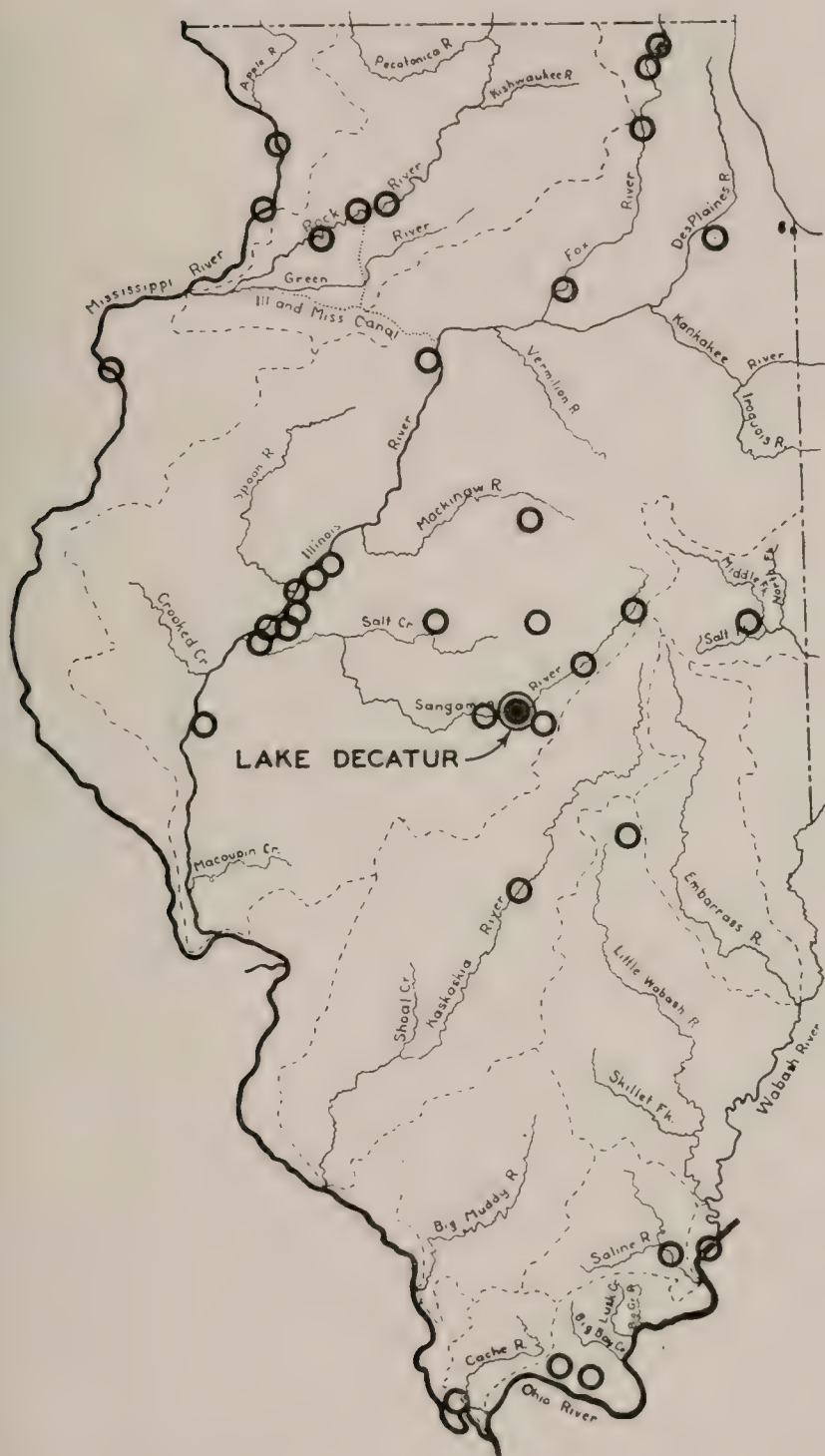


Fig. 13.—Illinois localities represented by age determinations of fish included in table 28.

In Illinois waters other than Lake Decatur, study of growth in fish more than a year old was based on scale samples from lakes or streams in 33 localities in widely scattered sections of the state, fig. 13. Lengths of fish having a like number of annual rings were averaged for each collecting period at each locality, table 28.

Table 28 shows wide differences in sizes of fish having a like number of annual rings. Some of these averages are not subject to direct comparison, since small fish in the samples were not always adequately represented. Especially was this true in several samples collected in 1931 and before (footnote 3, table 28). Some collections were made during the active growing period of the fish collected, while others were made between growing periods. In the case of summer collections, it was not known whether the outer ring on a scale was the ring of the current year or of the preceding year.

Data on some of the outstanding examples of white crappie populations containing fast-growing and slow-growing fish are recorded in table 29. Populations containing slow-growing fish like those found in Weldon Springs, Lincoln, and Homewood lakes are termed "stunted." Such populations contain only a small percentage of crappies over 8 inches in length even though a large percentage are 3 to 5 years old. Growth in these populations is not so abnormally slow during the first 2 years as during the third year and later.

Of all Illinois waters sampled, Horseshoe Lake, in Alexander County, contained the largest white crappies. In this lake, annual growth increments were especially large among fish that had lived beyond the third year. Also, the rate of survival of fish beyond the fourth year appears to have been exceptionally high. The Horseshoe Lake population has been analyzed previously by Thompson & Bennett (1938). Probably the good growth observed in this lake was due to the recent origin of the population. The lake was drained in 1930 and refilled and restocked in 1931.

Lake Decatur, where growth was rapid, and Homewood, where growth was slow, table 29, are in the same central Illinois locality; Homewood Lake was formed by

damming one of the small valleys tributary to Lake Decatur.

Growth Rates in Out-of-State Waters.—Growth of the white crappie has been studied in three neighboring states: at Reelfoot Lake, Tennessee, by Schoffman (1940); at Lake of the Ozarks, Missouri, by Weyer (1940); in Indiana lakes by Ricker & Lagler (1942) and Johnson (1945); and in three TVA reservoirs, two in Tennessee and one in North Carolina, by Stroud (1949). The growth rates observed in these bodies of water fall approximately in the range observed in Illinois waters.

Eschmeyer & Jones (1941) found that in the early years of impoundment of Norris Reservoir, the black crappies there grew at a much faster rate than has yet been observed in Illinois white crappies. The first brood of black crappies hatched in Norris Reservoir (in 1937) averaged 11.5 inches (total length) when they had completed two summers of growth. (The best recorded growth for an adequate sample of Illinois white crappies with two completed summers was found at Lake Decatur in the winter collections of 1936-37. The fish of these collections averaged 8.6 inches in length.) The third brood of black crappies hatched at Norris Reservoir (in 1939) grew at about the same rate in their first summer as Illinois white crappies of the same age, but the rate of growth in their second year, when they reached 8.9 inches, was faster than the best average for Lake Decatur.

Eschmeyer & Jones (1941) attributed the good growth in the early years at Norris Reservoir to abnormal richness of the lake in basic food elements and lack of severe competition.

SUMMARY

This paper is based primarily on an intensive study of the white crappie in Lake Decatur, Macon County, Illinois, where sampling was carried on at 1- to 2-month intervals the year round from late 1935 to late 1939. It is based in part on additional information obtained from various fisheries investigations carried on by members of the aquatic biology staff of the Natural History Survey during an 18-year period beginning in 1927.

The white crappie and the black crappie, both important as sport fishes in Illinois, are abundant throughout the state. The white crappie generally outnumbers the black in small streams or creeks and in artificial lakes of all sizes. The black tends to be the more common species in the deep glacial lakes of northeastern Illinois. In the larger rivers and in the bottomland lakes preponderance of one species over the other varies from lake to lake and from one part of the channel to another.

At the time of this study, fishermen used various methods of angling, some uncommon, and various kinds of baits in fishing for white crappies in Illinois. At Lake Decatur they caught white crappies principally from March 1 to June 1.

In year-round hoop-net fishing at Lake Decatur, the poorest catches were made in the summer.

White crappies require 2 years or, sometimes, 3 years to reach sexual maturity. The smallest ripe female observed in Illinois measured 5.6 inches total length. Dark breeding coloration was found in most males of breeding size from April to June (or July) and was seen in the female. Ripe females (with mature eggs) were found in Illinois as early as May 6 and as late as July 13; ripe males as early as May 16 and as late as June 4. The height of the Illinois spawning season is probably late May or early June. It appears that only a portion of the eggs of ripe females are laid and that perhaps a considerable number of unlaid eggs are absorbed.

Crappies spawn under a variety of conditions of bottom, water depth, and proximity to vegetation, embankments, and wooden structures. They seem to show a preference for depositing their eggs in plant material, but they do not require aquatic plants for that purpose.

Net samples showed a predominance of males among young white crappies, a predominance of females among older white crappies. They showed a temporary scarcity of males in late spring and early summer.

Lymphocystis, the most common disease observed in white crappies, was found in 9.5 per cent of the white crappies in one locality.

Comparisons in the relative plumpness of the members of different length classes and broods were based on the coefficient of condition, K . Small fish usually began their annual growth before large fish and showed earlier summer gains in condition. Large fish reached peak condition in late fall or early winter; small fish reached peak condition in midsummer. Small fish showed condition losses in late summer and additional losses in early spring. Large fish suffered condition losses mainly in spring and early summer.

At most times of the year the K values were higher in large white crappies than in small ones. Differences in K values were least apparent in June and July when the large fish were at the low point in the condition cycle and the small fish were nearing the top of the cycle. K values were approximately the same in males and females of the same size categories, irrespective of time of year.

Evidence obtained at Lake Decatur indicates that the annual rings on the scales of white crappies are not invariably formed at the rate of one ring for each year of life and that the rings are not formed at exactly the same time of year.

The sizes of white crappies caught in the nets at Lake Decatur fluctuated strongly from year to year. Large sizes were abundant only in alternate years. Disappearance of large sizes is believed to have been due to large-scale summer mortality (heavier some summers than others).

Lake Decatur crappie broods were generally short lived. Broods were usually not conspicuous in net catches beyond the second or third year of life. One brood disappeared completely at the age of 3 years and 3 months; another brood at 4 years and 4 months.

Dates of annulus formation were obtained for 4 consecutive years at Lake Decatur. Start of growth ranged from early May in some fish to late August or later in others.

The annual growth period at Lake Decatur varied for most individual fish from about 2 to 6 months. Some individuals failed to grow at all in 1935 and 1937.

The average observed lengths of white crappies falling into various annual ring classes were recorded for Lake Decatur

and 33 other Illinois localities. The annual growth increments of the white crappies at Lake Decatur varied widely from year to year. This was true particularly of fish in the second and third years of life;

which grew exceptionally well in 1936 but made little or no growth in 1935 and 1937.

Only small differences in the growth rates of males and females were found among the white crappies of Lake Decatur.

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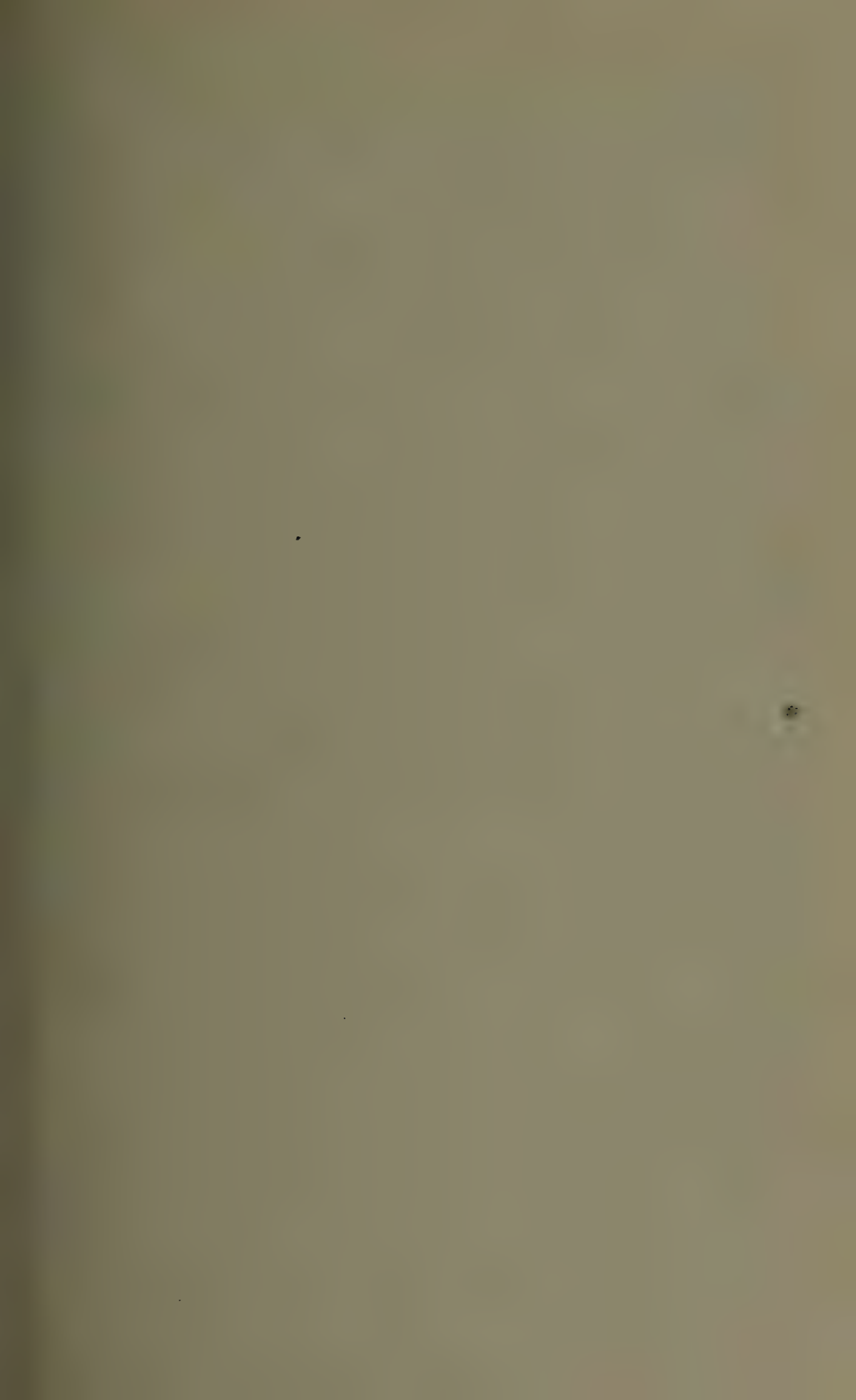
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BULLETIN

of the

ILLINOIS NATURAL HISTORY SURVEY

HARLOW B. MILLS, *Chief*

Commercial and Sport Fishes of the Mississippi River

*Between Caruthersville, Missouri,
and Dubuque, Iowa*

PAUL G. BARNICKOL

WILLIAM C. STARRETT



Printed by Authority of the
STATE OF ILLINOIS
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DEPARTMENT OF REGISTRATION AND EDUCATION
C. HOBART ENGLE, *Director*

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NATURAL HISTORY SURVEY DIVISION
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Volume 25

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Article 5

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This paper is a contribution from the Section of Aquatic Biology.

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Channel catfish, one of the species important to the commercial catch of the Mississippi River.

Commercial and Sport Fishes of the Mississippi River

*Between Caruthersville, Missouri,
and Dubuque, Iowa**

PAUL G. BARNICKOL†
WILLIAM C. STARRETT‡

IN December, 1943, conservation representatives from the states of Illinois, Iowa, Missouri, Minnesota, and Wisconsin, from the United States Fish and Wildlife Service, and from other interested agencies met at Dubuque, Iowa, and formed the Upper Mississippi River Conservation Committee (Smith 1949). This group was organized for the purpose of sponsoring studies of the fishery and wildlife resources of the Mississippi River from Caruthersville, Missouri, to Hastings, Minnesota. The studies were designed to serve as a basis for making scientifically sound recommendations for the management of these resources. At that time the fish and game codes of the member states were at variance with one another in certain provisions, and some practices that were legal in the waters of the Mississippi bordering one state were illegal in the waters within the jurisdiction of another immediately across the river.

To facilitate the actual projection of biological investigations, two technical committees were formed within the Conservation Committee. These were the Technical Committee for Fisheries and the Technical Game Committee. To them were assigned the duties of planning research and reporting the progress of research to the Conservation Committee at its annual meetings.

* This investigation was conducted under the auspices of the Technical Committee for Fisheries of the Upper Mississippi River Conservation Committee.

† Formerly Ichthyologist, Illinois Natural History Survey; now Chief Biologist of the Fisheries Section of the Missouri Conservation Commission.

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Basic to a sound management program for the upper Mississippi fishery was a knowledge of the status of various species of fish present in the river. Commercial fishery statistics were not adequate because they included several species under single groupings, as buffalofishes and catfishes, and because in recent years they failed to include sport fishes and other species closed to commercial fishing.

Because state agencies were restricted in their research activities by state boundaries (the United States Fish and Wildlife Service was the only agency involved that was free to finance projects without regard to state boundaries), it became necessary to subdivide the upper Mississippi River fishery investigations into upper and lower co-operative units—the upper unit involving Wisconsin, Minnesota, and northern Iowa, and the lower unit involving Missouri, southern Iowa, and Illinois.

Actual field operations were begun in the Missouri-Illinois part of the southern unit in March, 1944, with the Conservation Commission of Missouri, the Illinois Department of Conservation, and the Illinois Natural History Survey participating. Two years later, in March, 1946, field operations were begun in the Iowa-Illinois part of the river with the Iowa Conservation Commission and the two Illinois agencies co-operating.

The entire investigation reported here was conducted under the auspices of the Technical Committee for Fisheries.

This paper is based on an analysis of the data relative to the species composition

of the fishes appearing in test-net collections taken in 1944 and 1946 with various types of commercial gear at 31 sampling stations between Caruthersville, Missouri, and Dubuque, Iowa. The gear included types that could not be used legally by commercial fishermen in some or all of the co-operating states.

The discussion is limited largely to the commercial and sport fishes of the river. The smaller-sized fishes, such as the minnows (Cyprinidae), seldom occurred in the test-net collections, as the minimum mesh used was 1 inch square. Minnow collections were made at many of the stations, and a list of the species appearing in these collections was recorded but is not presented here.

The writers believe that, regardless of any shortcomings of the sampling methods employed in this study, the data are extensive enough to allow a rough estimate of the status of the various commercial and game fishes now occurring in the Caruthersville-Dubuque section of the Mississippi.

Acknowledgment is made to the following persons for their various contributions to the progress of the researches reported in this paper: Mr. W. E. Albert, Mr. Daniel Avery, Mr. James S. Ayars, Dr. Reeve M. Bailey, Dr. George W. Bennett, Mr. Leonard Durham, Dr. T. H. Frison (now deceased), Dr. B. Vincent Hall, Dr. Donald F. Hansen, Dr. G. B. Herndon and associates, Mr. Don W. Kelley, Mr. Jacob H. Lemm, Dr. Harlow B. Mills, Mr. Sam A. Parr, Dr. Hurst H. Shoemaker, Mr. Everett B. Speaker and associates, and Dr. David H. Thompson.

Financial support of this investigation was given by the conservation departments of the states of Illinois, Iowa, and Missouri, and by the Illinois Natural History Survey, all co-operating under the Upper Mississippi River Conservation Committee program.

THE MISSISSIPPI RIVER

The length of the Mississippi River from its source at Lake Itasca to its mouth at Head of Passes is 2,470 miles (Mississippi River Commission 1940:1). This great river and its tributaries drain a total area of about 1,244,000 square miles, including all or parts of 31 states and 2

Canadian provinces: New York and Pennsylvania farthest east, Wyoming and Montana farthest west, Alberta and Saskatchewan farthest north. The investigation reported here covers that part of the Mississippi River between Caruthers-



Fig. 1.—The Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa; shown is the location of field sampling stations used during the fisheries survey of 1944 and 1946. The river distance between Caruthersville and Dubuque is 689 miles.

ville, Missouri, and Dubuque, Iowa, a distance of 689 miles or 28 per cent of the total length of the river, fig. 1. This section of the river includes 306 miles of the lower Mississippi, designated hereafter as MR-C (mouth of the Missouri River to Caruthersville), and 383 miles of the upper Mississippi, designated as D-MR (Dubuque to the mouth of the Missouri River).

Early Descriptions

The Mississippi River was discovered in the sixteenth century by an expedition headed by Hernando de Soto. Later explorations were made on the Mississippi by such well-known historical personages as D'Iberville, Joliet, Marquette, and La Salle.

The "Gentleman of Elvas," a Portuguese member of the De Soto expedition, stated that "The river was of great depth and of a strong current. The water was always muddy. There came down the river continually many trees and timber, which the force of the water and stream brought down. There was a great store of fish in it of sundry sorts, and most of it differing from the fresh water fish of Spain" (Saxon 1927:78).

Thomas Jefferson (1801:11) wrote the following description of the river in about 1780: "The Mississippi, below the mouth of the Missouri, is always muddy and abounding with sand bars, which frequently change their places. However, it carries 15 feet water to the mouth of the Ohio, to which place it is from one and a half to two miles wide, and thence to Kaskaskia from one mile to a mile and a quarter wide. Its current is so rapid, that it never can be stemmed by the force of the wind alone, acting on sails. Any vessel, however, navigated with oars, may come up at any time, and receive much aid from the wind."

Reclus (1859:262) in his paper on the Mississippi mentioned the yellow water of the Missouri River and the blue water of the Mississippi at the confluence of the two rivers.

Prior to the construction of locks and dams, two rapids were present in the river between Dubuque and the mouth of the Missouri River. The upper were

between Le Claire, Iowa, and Rock Island, Illinois, and the lower at Keokuk, Iowa.

Glazier (1891:314) in describing his trip down the Mississippi in 1881 stated that "We found the current of the Mississippi below the mouth of the Missouri much stronger than we had observed it to be since passing the Keokuk Rapids."

Floods and Levees

Floods along the Mississippi have been reported since the river's discovery. A member of the De Soto expedition in 1543 wrote the first description known of a Mississippi flood. The flood began about the tenth of March and reached its peak about 40 days later. "The inundated areas are said to have extended for twenty leagues on each side of the river" (Mississippi River Commission 1940:8).

Jefferson (1801:11-2) wrote the following regarding floods on the Mississippi: "These floods begin in April, and the river returns into its banks early in August. The inundation extends further on the western than eastern side, covering the lands in some places for 50 miles from its banks. Above the mouth of the Missouri, it becomes much such a river as the Ohio, like it clear, and gentle in its current, not quite so wide, the period of its floods nearly the same, but not rising to so great a height."

The delta with its fertile land early attracted many settlers. This alluvial valley extends up the river as far as Cape Girardeau, Missouri. "In the Alluvial Valley the Mississippi River is an aggrading, or soil-building stream. In time of flood the river goes out of its banks, dropping its load of sediment as it goes. This action is due to the slowing up of the waters as they leave the river's channel; and the larger share of this material settles on or near the edges of the stream. For this reason the banks are generally from 10 to 15 feet above the lowlands away from the river. The slope away from the river is usually steepest for the first mile away from the river banks" (Mississippi River Commission 1940:9).

For more than two centuries man has used levees in defense of his rich soil and cities against the flooding torrents of the Mississippi. By 1727, a levee along the

Table 1.—Stations where fish collections were taken during 1944 and 1946 on the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, with inclusive dates, pool numbers, number of net days at each station, and river stages in feet.*

STATION	INCLUSIVE DATES	MILES BELOW DU- BUQUE STATION	POOL No.	NUMBER OF NET DAYS	RIVER STAGE AT MUSCATINE	RIVER STAGE AT CAPE GIRAR- DEAU
<i>1944</i>						
Caruthersville, Mo.	April 6-12.	689	—	42.54	7.7	19.2
Tiptonville, Tenn.	April 15-May 10.	665	—	111.70	11.3	38.9
Cairo, Ill.	May 18-24.	573	—	54.10	14.2	27.1
Cape Girardeau, Mo.	May 26-31.	529	—	61.94	16.7	28.8
Grand Tower, Ill.	June 2-9.	499	—	73.13	12.3	30.3
Chester, Ill.	June 11-15.	468	—	38.99	11.5	26.5
Ste. Genevieve, Mo.	June 18-24.	454	—	46.14	15.8	27.5
Crystal City, Mo.	June 25-30.	429	—	62.19	17.5	30.4
Cliff Cave, Mo.	July 2-8.	412	—	61.36	15.0	29.0
Mouth Missouri R., Mo.	July 10-15.	383	—	62.86	10.8	25.8
Grafton, Ill.	March 22-30.	358	26	42.64	9.8	24.9
Grafton, Ill.	July 17-25.	358	26	74.30	9.4	21.8
Grafton, Ill.	Sept. 22-27.	358	26	93.31	5.7	13.5
Winfield, Mo.	July 27-Aug. 2.	337	25, 26	85.92	7.9	18.8
Hamburg, Ill.	Aug. 3-9.	320	25	96.60	6.9	16.3
Louisiana, Mo.	Aug. 12-17.	295	24	66.71	6.6	15.5
Cincinnati Landing, Ill.	Aug. 19-23.	281	24	64.90	6.3	15.1
Hannibal, Mo.	Aug. 25-30.	267	22	82.97	5.7	16.2
Quincy, Ill.	Sept. 2-6.	256	22	105.20	6.2	20.7
Canton, Mo.	Sept. 8-13.	236	21	100.82	5.5	15.9
Warsaw, Ill.	Sept. 14-19.	218	20	99.99	6.0	13.0
<i>1946</i>						
Burlington, Iowa.	April 10-22.	178	19	143.72	10.2	20.6
Oquawka, Ill.	April 24-May 5.	159	18	135.80	7.3	16.6
New Boston, Ill.	May 7-18.	143	18	155.00	6.4	22.1
Muscatine, Iowa.	May 19-30.	134	17	160.00	5.9	19.8
Fairport, Iowa.	June 2-13.	118	16	158.85	6.8	17.4
Andalusia, Ill.	April 1-7.	103	16	98.18	15.0	27.8
Andalusia, Ill.	June 18-26.	103	16	155.67	11.4	22.8
Andalusia, Ill.	Sept. 15-24.	103	16	196.53	6.0	12.7
Pleasant Valley, Iowa.	June 28-July 9.	87	15	151.68	10.0	21.3
Cordova, Ill.	July 11-22.	75	14	150.17	9.9	18.8
Fulton, Ill.	July 24-Aug. 4.	57	14	152.39	5.6	13.0
Sabula, Iowa.	Aug. 6-17.	44	13	160.31	5.3	11.6
Bellevue, Iowa.	Aug. 19-30.	17	12	188.40	5.0	17.6
Dubuque, Iowa.	Sept. 1-12.	0	12	192.83	6.1	10.2

* The 1944 river stage data from the United States Department of Commerce (1946); the 1946 river stage data furnished by Ray K. Linsley, Jr., Acting Chief of Division, Climatological and Hydrologic Services, Washington, D. C. Flood stage is 32 feet at Cape Girardeau, Mo.; 15 feet at Muscatine, Iowa.

Mississippi at New Orleans had been completed to a length of 5,400 feet (Mississippi River Commission 1940:10).

In 1850 the Federal Government approved an act which encouraged the reclaiming of the alluvial land along the Mississippi below the mouth of the Ohio River (Saxon 1927:261). In 1879 the Mississippi River Commission was created and placed in charge of flood control on the Mississippi (Saxon 1927:266).

In that part of the Mississippi River covered by the present investigation, levees

and drainage districts border much of the stream up as far as Muscatine, Iowa. Below the mouth of the Missouri River the levees are more apparent than along the upper river and they give the observer an impression that the river is hemmed in by them.

High-water conditions prevailed throughout the 1944 investigation of the MR-C section of the river, as shown in table 1. In several instances during this survey, test-netting was done over flooded land formerly planted in corn or cotton.

Improvements for Navigation

The exciting days of steamboating on the Mississippi described by Mark Twain and others are just about gone. Steam-

boats are being replaced by diesel-powered towboats capable of pushing huge barges loaded with coal, grain, oil, and other commodities. During the period of World War II approximately 1,980 war



Fig. 2.—Lock and Dam No. 25 just above the Winfield, Missouri, sampling station. The swiftness of the current below the dam is quite perceptible. Photo by courtesy of the United States Army Corps of Engineers, Upper Mississippi Valley Division, St. Louis, Missouri.



Fig. 3.—Lock and Dam No. 24 just below the Louisiana, Missouri, sampling station on the Mississippi River. Photo by courtesy of the United States Army Corps of Engineers, Upper Mississippi Valley Division, St. Louis, Missouri.



Fig. 4.—Lock and Dam No. 22 just below the Cincinnati Landing, Illinois, sampling station. Photo by courtesy of the United States Army Corps of Engineers, Rock Island District.



Fig. 5.—Lock and Dam No. 11, and Pool No. 12, from Eagle Point Park, near Dubuque, Iowa. Photo by courtesy of the United States Army Corps of Engineers, Rock Island District.

vessels were passed through the lock at Alton, Illinois (War Department Corps of Engineers 1946:7). These vessels were constructed inland and outfitted for sea at New Orleans, Louisiana.

The use of the river for navigation and the construction of levees for drainage districts and flood control have brought about many changes on the river. As early as 1824 an act was passed by Congress

appropriating \$75,000 for the improvement of the Mississippi by "snagging" from the mouth of the Missouri River to New Orleans. The first permanent improvement on the river came in the building of a pier at St. Louis, Missouri, to give direction of current. This construction was authorized by acts passed in 1836 and 1837. Later, the Keokuk and Rock Island rapids were improved for naviga-

tion. An act in 1872 authorized improvement of the river between Alton and the mouth of the Meramec River by obtaining channel depths through revetments, solid dikes, and dams. A comprehensive project was approved in 1881 for continuous improvement of the river between the mouth of the Ohio River and St. Louis to secure a minimum depth of 8 feet by using revetments, permeable dikes, and contraction of the low water channels to an approximately uniform width of 2,500 feet. This project was modified by acts passed in 1895 and 1896 providing for the maintenance of a channel 250 feet wide and 9 feet deep by regulating works and dredging. The project was again modified in 1905, providing that the use of regulating works be supplanted by extensive dredging operations. Later, dredging alone proved unsatisfactory; in 1910 regulating works were again approved, and channel depths of 6 feet from the mouth of the Missouri to St. Louis and 8 feet from St. Louis to the mouth of the Ohio were authorized. In 1927 and 1930, acts of Congress authorized a channel depth of 9 feet between St. Louis and the mouth of the Ohio, with a channel width of 300 feet, and a channel depth of 9 feet from the mouth of the Illinois River to St. Louis, with a channel width of 200 feet (War Department Corps of Engineers 1940:5-6). A project for the improvement of the Chain of Rocks Reach in the St. Louis area was approved in 1945. In this 7-mile reach, at low water the stream gradient averaged approximately 1.5 feet per mile in contrast to 0.5 foot above the Chain of Rocks and 0.6 foot from St. Louis to Cairo, Illinois (Smyser 1947:5).

General improvement of the upper Mississippi for navigation between the mouth of the Missouri and St. Paul, Minnesota, was authorized by Congress in 1878. This was to be accomplished by the use of wing dams and closure of chutes to secure a depth of 4.5 feet, eventually to be increased to 6 feet. In the period 1888 to 1906 "the rock cut through Rock Island Rapids was improved to a width of 400 feet and a depth of 6 feet." In 1905 an act was passed to replace the locks and lateral canal at Keokuk with a power dam and navigation locks (War Department Corps of Engineers 1940:6).

This project was practically completed in 1913 (Coker 1914:5). An act passed in 1907 provided for a 6-foot channel from Minneapolis, Minnesota, to the mouth of the Missouri River to be accomplished by contraction works, as in the project of 1878, supplemented by dredging and a lateral canal with a navigation lock around the upper portion of the Rock Island rapids at Le Claire (War Department Corps of Engineers 1940:6).

The Board of Engineers for Rivers and Harbors concluded after an investigation that canalization of the Mississippi from the mouth of the Illinois to Minneapolis was the most feasible and economical method of obtaining a dependable 9-foot channel for navigation; plans included the construction of approximately 24 locks and dams (United States 72d Congress, 1st Session, 1932:2, 27). An act of 1930, as modified in 1935, authorized improvement of the Mississippi River from Minneapolis to the mouth of the Missouri River by means of locks and dams supplemented with dredging to provide a channel 9 feet in depth (War Department Corps of Engineers 1940:6). The upper Mississippi from Alton north was canalized by the time the present investigation was started in 1944, figs. 2, 3, 4, and 5. In the Alton-Dubuque section there were 14 locks and dams (Nos. 12-26, excluding 23).

Influence of the Missouri

In the above discussion the descriptions of several early writers were quoted regarding the confluence of the Missouri and Mississippi rivers and the influence of the Missouri on the Mississippi. Prior to agricultural development of the prairies, the upper Mississippi was apparently a relatively clear river, and below the mouth of the Missouri it was always muddy. The D-MR section of the Mississippi was found by the survey party in 1944 and 1946 to be quite muddy; however, it appeared less muddy than the MR-C section. In 1944 Platner (1946:16) found that the turbidity of the Mississippi just above the mouth of the Missouri averaged 300 ppm, whereas, below the mouth of the Missouri it increased to an average reading of 1,880 ppm. At Caruthersville, 306 miles below the mouth of the Missouri

this high turbidity had diminished only slightly. The turbidity of the Mississippi, according to Platner (1946:12), is caused largely by erosion silt with some detritus. In 1921 Galtsoff (1924:371) found the water in the upper Mississippi muddy even at low water stages and progressively more turbid as he moved downstream.

The current of the Mississippi is swifter below the mouth of the Missouri than above. This difference in current was apparent before canalization, as evidenced by Glazier (1891:314).

According to the War Department Corps of Engineers (1940:3) the velocities in the current of the Mississippi between the mouth of the Wisconsin River and Alton may vary from about 2 miles per hour at usual pool stages to about 4 miles per hour at high water. In the uncanalized or open-river section below Alton, the velocities range from 2.0 to 5.5 miles per hour, except through the Chain of Rocks near St. Louis. In this region velocities as high as 8 miles per hour may occur at both extreme high- and extreme low-water stages. In the pools formed by the locks and dams in the Alton-Dubuque section, the swiftest current appears in the upper parts of the pools.

The bottom of the river proper in the MR-C section is largely sand with occasional silt or mud. The flooded areas in which netting operations were conducted had chiefly mud bottom. The bottom of the canalized D-MR section of the Mississippi varies with location in the pools. In the upper parts of the pools where the current is swift, the bottoms are sand and gravel, whereas, in the middle and lower reaches of the pools, the bottoms are largely silt. The silting in the canalized section of the river is a result of reduction in current caused by the dams. Ellis (1931:4-5) made oxygen determinations of the Mississippi River in the Keokuk area prior to the canalization of the river above the dam at Keokuk (Lock and Dam No. 19). He found that the water before reaching the Lake Keokuk basin was carrying over 20 per cent more oxygen than after it was impounded in the basin. Some 30 miles below Dam No. 19, at La Grange, Missouri, the oxygen content of the water was 10 to 15 per cent less than above the impoundment.

Platner (1946:26) found that the river has a distinct seasonal oxygen pulse. In midwinter, when the river was frozen over with 4 to 8 inches of ice, the dissolved oxygen ranged from 12.40 ppm to 14.95 ppm. During times of low water, in August and September, it ranged from 3.00 to 7.10 ppm. In periods of high water it ranged from 4.30 to 11.50 ppm.

The flooded bottomlands in the canalized D-MR section of the river are less encroached upon by drainage districts, and they seem to provide more suitable backwater and sloughs for spawning, than the bottomlands in the extensive levee and drainage districts of the MR-C section.

On the silt bottom of Lake Keokuk (Pool No. 19), Ellis (1931:8-9) found a few fresh-water mussels near shore; otherwise, on this bottom he found little besides sludge worms, bloodworms, *Corethra* (*Chaoborus*), a few snails of the pulmonate group, tiny bivalves of the genus *Musculium*, and several species of leeches. In the area free of silt, such as on cinders, stones, and water-logged portions of trees, he found large numbers of caddisfly and Neuroptera larvae, flatworms, beetle larvae, and occasionally a few specimens of crayfish, gomphids (dragonfly nymphs), and leeches.

Pollution

Erosion silt is a constant form of pollution in the Caruthersville-Dubuque section of the Mississippi River. Although this form of pollution has long been associated with that part of the Mississippi below the mouth of the Missouri, it was not generally noted in the upper part of the river until after the development of intensive farming in the Middle West.

That silting tends to limit the reproduction of aquatic life has been demonstrated previously. Silting was pointed out as having a detrimental effect on trout and salmon eggs (Smith 1940:229) and on aquatic insects and other invertebrates (Ellis 1931, 1936). In the Des Moines River, high water combined with the river's increased silt load in a period of flood was shown to be an important limiting factor in the spawning success of minnows and other kinds of fishes (Starrrett 1951:23).

The impounding of the upper Mississippi with a series of dams created favorable conditions for silting in that section of the river. This impounding was done largely during the thirties, and the present investigation was made perhaps too soon following this period to demonstrate the possible maximum effects that siltation may have on the upper Mississippi fishery.

Platner (1946:71-2) found pollution in the Mississippi limited largely to local areas below cities and industrialized sections. "Even though the volume of water is large enough and the dilution is great enough to render these pollutants harmless to the present fish fauna of the Mississippi River, one must remember that each small amount of material narrows the safety margin of the river." Platner concluded from his chemical studies that the river was not in a critical condition. He further concluded that in the upper section of the river, that is, north of the 420-mile mark above the mouth of the Ohio River (about 4 miles above Oquawka, Illinois), a more "favorable position" existed than in the lower section below mile 420. "Comparing the water quality of the Mississippi River with waters producing good fish fauna, it would be rated as good."

Ellis (1943) conducted a pollution study on the Mississippi River between Chain of Rocks (St. Louis area) and Cairo. He made this study in relation to garbage introduced into the river at St. Louis. In September of 1931 and 1934, during periods of low water, he found that the Mississippi lost a considerable portion of its dissolved oxygen load in the immediate vicinity of St. Louis. Below the city it made a temporary recovery, and between Crystal City, Missouri, and Cape Girardeau it again lost a large amount of its oxygen load. Between Crystal City and Claryville, Missouri, Ellis (1943:8) recorded a maximum of 3.86 ppm of total ammonia. He stated that "This total ammonia of approximately 4 p.p.m. represents a considerable nitrogenous load and shows definitely that the nitrogenous wastes from the St. Louis area are projected downstream 65 or 70 miles before the maximum ammonia production is reached." Below the mouth of the Ohio River, at Wickliffe, Kentucky, the total ammonia content

dropped to 1.28 ppm. In 1944 Platner (1946:39) determined that from mile 580 above the mouth of the Ohio to mile 170 above (St. Louis area) the ammonia value ranged from 0.0 to 0.1 ppm and averaged 0.06 ppm. Below St. Louis the ammonia value increased slightly to an average of 0.12 ppm.

During the Caruthersville-Dubuque investigation, notes were taken on obvious pollution conditions existing in this section of the river. The fishery studies in the MR-C section were carried out largely during a period of high water, and in such a period the relative amount of pollutant other than silt is reduced. Commercial fishermen at Ste. Genevieve, Missouri, which is about 55 miles below St. Louis, complained that fishes they catch during the summer low-water stage frequently have an oily or gassy flavor. In the opinion of the fishermen this flavor is attributable to wastes discharged into the river at St. Louis. At Crystal City, also, fishermen registered complaints regarding pollution. In the vicinity of Cliff Cave (12 miles below St. Louis) test nets set in channels became clogged with masses of paper and partially disintegrated ground garbage discharged through the sewers of St. Louis. There, also, commercial fishermen reported that the fish in the area have an oily or gassy flavor; however, fish taken there in early July (Cape Girardeau gage 29.0 feet, table 1) which were served to members of the research party did not appear to have such a flavor. Perhaps this foreign taste is discernible only at low stages of the river when dilution is not sufficient to overcome the effect of the causal agent.

In 1947 commercial fishermen in the vicinity of Valmeyer, Illinois (28 miles below St. Louis), complained that often half of their catches were discarded because of an unpleasant taste resulting from pollution.

Recently Starrett & Harth (1950:8) reported that since 1948 a serious pollution problem has existed on the Mississippi from below Dam 26 to Cairo, and that commercial fishing is now almost nonexistent from the St. Louis area to the mouth of the Kaskaskia River.

Above the mouth of the Missouri River, pollution was observed in the vicinity of

two Illinois stations, Warsaw and Cordova. Warsaw is located about 1.5 miles below the mouth of the Des Moines River. This river receives a rather heavy load of pollution from the city of Keokuk, as was evidenced by the accumulation of sewage and other debris on the test nets. A large portion of this pollution in the Des Moines evidently comes from packing plants. Across the Mississippi River from Keokuk and just below Hamilton, Illinois, the malt wastes from a brewery are discharged into the river. It was obvious from the poor catches of commercial fishes in the test nets that the fish population is adversely affected by the pollution for several miles below Keokuk. According to local reports, commercial fishermen avoid setting their nets within the first few miles downstream from Keokuk on the Iowa side because of the unhealthy appearance of fishes that have been taken at that location. Carp taken in the test nets there appeared to have a rather milky coloration, and many of them showed a form of pop-eye. It was reported locally that, during the winter season, fishermen operate their nets on the Illinois side of the river near Warsaw to catch carp that apparently feed upon brewery waste and become very fat.

Commercial fishermen at Cordova complained that their hoop nets sometimes became clogged with a slimy substance that was later reported to be a filamentous organism attributed to conditions produced by wastes discharged from plants at Clinton, Iowa, 15 miles upstream. Seines became so loaded with this filamentous growth that they could not be hauled to shore and landed. No ill effect from the filamentous growth or the waste material supposedly responsible for it was observed on the fish at Cordova; in fact, the fish taken there appeared to be more plump than those in the usual catches taken elsewhere on the river. The local fishermen reported no mortality of fish or ill flavor of fish as a result of the waste material.

MATERIALS AND METHODS

In the 2 years of this investigation, collections were taken at 31 different field stations, fig. 1. One station in each year was designated as a key station, Grafton in 1944 and Andalusia in 1946, table 1.

Each of the key stations was sampled three times during an 8-month period of field operations as a means of obtaining data on changes in a local fishery.

Usually sampling at a station covered 5 days. However, at some stations more time was spent because of certain unforeseen difficulties, such as those involving bad weather, poor catches, mechanical trouble, or the locating of fishing areas.

Descriptions of the habitats at the field stations are given in Appendix A. Data on the catches made at these stations are presented in tables 2, 3, 4, and 5 and Appendix B, tables 1 and 2.

Netting Operations

The Illinois Natural History Survey's laboratory boat, the *Anax*, was used as field headquarters during this investigation. All fish caught were brought to the laboratory boat. Aboard the boat, technicians measured and weighed each fish, removed scales or vertebrae for growth studies, and recorded the sex and gonad condition of the fish. The haul made with each type of gear, from each station, and in each fishing period was tabulated as an individual catch, and a record was made of specific information on habitat in which gear was fished.

The following types of fishing gear were used during the survey:

- 25-foot *Common Sense* minnow seine (mesh $\frac{1}{4}$ inch)

- 100-yard trammel nets (mesh $1\frac{1}{2}$, 2, and 3 inches)

- 100-yard or 200-yard seine (mesh 1 inch)

- Hoop nets (mesh 1, $2\frac{1}{2}$, and 3 inches)

- Wing nets, with and without leads (mesh 1, $1\frac{1}{2}$, and $2\frac{1}{2}$ inches)

- Trap net (mesh $1\frac{1}{4}$ inches)

- Basket trap

- Trotline

The poundage and numbers of fishes caught by the various types of fishing gear are summarized in tables 2, 3, 4, and 5. Data on the fishes taken in the minnow seine hauls are not included in this paper. Selections of fishing sites were made by two field assistants of the Illinois Natural History Survey, Jacob H. Lemm and Daniel Avery, who had previously been commercial fishermen. Conversation with

Table 2.—Numbers of fish caught with various types of fishing gear in the Mississippi River at stations from Caruthersville, Missouri, to Warsaw, Illinois, inclusive.

STATION	1-INCH MESH WING NETS WITH LEADS	1-INCH MESH WING NETS WITHOUT LEADS	1½-INCH MESH WING NETS	2½-INCH MESH WING NETS	2½-INCH MESH HOOP NETS	UNCLAS- SIFIED WING NETS AND HOOP NETS	TOTAL WING NETS AND HOOP NETS	TRAM- MEL NETS	ANGLING	BASKET TRAPS	SEINES	TOTAL NUMBER OF SPECI- MENS
Caruthersville, Mo.....	60	153	—	2	—	243	458	—	—	—	—	458
Tiptonville, Tenn.....	89	183	—	4	23	345	644	—	—	—	—	644
Cairo, Ill.....	416	196	26	—	7	—	645	—	—	—	—	645
Cape Girardeau, Mo.....	—	233	—	57	—	—	290	—	—	4	—	294
Grand Tower, Ill.....	262	330	88	38	—	—	718	—	—	23	—	741
Chester, Ill.....	216	85	53	—	—	—	354	—	—	3	—	357
Ste. Genevieve, Mo.....	137	191	132	133	—	—	593	—	—	1	—	594
Crystal City, Mo.....	157	174	58	69	21	—	479	—	—	—	—	479
Cliff Cave, Mo.....	—	200	64	87	14	—	365	—	—	3	—	368
Missouri River (mouth).....	190	871	81	67	34	—	1,243	—	1	13	—	1,257
Grafton, Ill. (March).....	1,139	82	—	22	—	—	1,243	—	—	—	—	1,243
Grafton, Ill. (July).....	434	381	174	31	5	—	1,025	9	—	—	—	1,034
Grafton, Ill. (Sept.).....	—	493	48	7	6	—	554	—	—	—	—	554
Winfield, Mo.....	—	572	56	56	13	—	697	—	—	9	361	1,067
Hamburg, Ill.....	89	490	50	49	11	—	689	12	—	4	43	748
Louisiana, Mo.....	—	247	33	11	2	—	293	—	—	13	31	337
Cincinnati Landing, Ill.....	60	140	23	19	4	—	246	—	—	—	—	246
Hannibal, Mo.....	29	208	26	17	13	—	293	—	—	—	38	331
Quincy, Ill.....	—	506	33	46	11	—	596	103	—	—	283	982
Canton, Mo.....	—	363	19	33	57	—	472	—	—	—	70	542
Warsaw, Ill.....	—	326	64	87	59	—	536	3	—	—	53	592
Total.....	3,278	6,424	1,028	835	280	588	12,433	127	1	73	879	13,513

Table 3.—Pounds of fish caught with various types of fishing gear in 1944 test-net operations in the Mississippi River at stations from Caruthersville, Missouri, to Warsaw, Illinois, inclusive.

STATION	1-INCH MESH WING NETS WITH LEADS	1-INCH MESH WING NETS WITHOUT LEADS	1½-INCH MESH WING NETS	2½-INCH MESH WING NETS	2½-INCH MESH HOOP NETS	UNCLAS- SIFIED WING NETS AND HOOP NETS	TOTAL WING NETS AND HOOP NETS	TRAM- MEL NETS	ANGLING TRAPS	SEINES	TOTAL POUNDS CAUGHT
Caruthersville, Mo.....	36.66	156.24	—	2.30	—	122.61	317.81	—	—	—	317.81
Tiptonville, Tenn.....	72.05	142.71	—	6.05	32.29	270.50	523.60	—	—	—	523.60
Cairo, Ill.....	522.34	196.14	32.27	—	12.28	—	763.03	—	—	—	763.03
Cape Girardeau, Mo.....	—	502.20	—	246.92	—	—	749.12	—	4.05	—	753.17
Grand Tower, Ill.....	344.36	355.43	99.71	118.48	—	—	917.98	—	12.69	—	930.67
Chester, Ill.....	309.45	157.72	115.97	—	—	—	583.14	—	2.16	—	585.30
Ste. Genevieve, Mo.....	211.79	341.45	226.83	283.42	—	—	1,063.49	—	2.23	—	1,065.72
Crystal City, Mo.....	137.35	254.28	121.07	196.49	80.12	—	789.31	—	—	—	789.31
Cliff Cave, Mo.....	—	367.73	152.51	242.85	37.30	—	800.39	—	8.00	—	808.39
Missouri River (mouth).....	133.82	574.26	141.22	169.59	97.79	—	1,116.68	—	11.41	—	1,128.21
Grafton, Ill. (March).....	631.51	62.83	—	51.44	—	—	745.78	—	—	—	745.78
Grafton, Ill. (July).....	222.47	239.46	72.82	71.59	16.28	—	622.62	10.15	—	—	632.77
Grafton, Ill. (Sept.).....	—	276.41	36.31	13.55	11.29	—	337.56	—	—	—	337.56
Winfield, Mo.....	—	425.60	46.88	116.49	25.32	—	614.29	—	6.88	245.27	866.44
Hamburg, Ill.....	35.97	302.29	37.22	74.57	33.08	—	483.13	14.45	—	35.46	534.11
Louisiana, Mo.....	—	216.32	36.24	19.32	2.47	—	274.35	—	1.07	46.10	334.40
Cincinnati Landing, Ill.....	49.15	211.99	42.53	30.07	14.50	—	348.24	—	13.95	—	348.24
Hannibal, Mo.....	28.17	237.60	32.59	42.34	77.82	—	418.52	—	—	29.57	448.09
Quincy, Ill.....	—	392.42	55.84	125.58	65.44	—	639.28	185.22	—	380.51	1,205.01
Canton, Mo.....	—	275.46	24.75	57.31	95.82	—	453.34	—	—	70.89	524.23
Warsaw, Ill.....	—	353.76	74.90	187.47	152.41	—	768.54	6.94	—	59.44	834.92
Total.....	2,735.09	6,042.30	1,349.66	2,055.83	754.21	393.11	13,330.20	216.76	62.44	867.24	14,476.76

Table 4. Numbers of fish caught with various types of fishing gear in 1740 test-net operations in the Mississippi River at stations from Burlington, Iowa, to Dubuque, Iowa, inclusive.

STATION	1-1/2-INCH MESH WING NETS	1-INCH MESH HOOP NETS	2 1/2-INCH MESH WING NETS	2 1/2-INCH MESH HOOP NETS	3-INCH MESH HOOP NETS	TOTAL WING NETS AND HOOP NETS	1 1/4-INCH MESH TRAPS	TRAMP- MESH NETS	SUCKERS	TROT- LINES	TOTAL NUMBER OF SPECI- MENS
Burlington, Ia.....	873	24	47	50	—	994	—	75	—	—	1,069
Oquawka, Ill.....	412	5	43	63	—	523	—	—	—	—	523
New Boston, Ill.....	1,095	33	54	52	—	1,234	—	41	50	2	1,327
Muscatinge, Ia.....	420	6	26	121	—	573	—	262	133	—	968
Fairport, Ia.....	351	1	55	30	—	437	—	69	85	—	591
Andalusia, Ill. (April).....	286	6	28	5	—	325	—	146	—	—	471
Andalusia, Ill. (June).....	561	30	90	124	—	805	—	56	101	—	962
Andalusia, Ill. (Sept.).....	387	13	27	24	45	496	69	335	167	—	1,067
Pleasant Valley, Ia.....	481	9	33	57	—	580	—	29	—	—	609
Cordova, Ill.....	440	35	23	31	—	529	—	72	58	—	659
Fulton, Ill.....	1,522	46	41	124	—	1,733	—	79	—	—	1,812
Sabula, Ia.....	698	16	15	41	—	770	—	48	—	—	818
Bellevue, Ia.....	458	7	15	29	—	509	107	65	—	—	681
Dubuque, Ia.....	727	20	29	37	—	813	73	81	—	—	967
Total.....	8,711	251	526	788	45	10,321	240	1,358	594	2	12,524

Table 5.—Pounds of fish caught with various types of fishing gear in 1946 test-net operations in the Mississippi River at stations from Burlington, Iowa, to Dubuque, Iowa, inclusive.

STATION	1-INCH MESH WING HOOP NETS	1-INCH MESH WING HOOP NETS	2½-INCH MESH WING HOOP NETS	2½-INCH MESH HOOP NETS	3-INCH MESH HOOP NETS	TOTAL WING NETS AND HOOP NETS	1¼-INCH MESH TRAPS	TRAM- MEL NETS	SEINES	TROOP- LINES	TOTAL POUNDS CAUGHT
Burlington, Ia.....	396.48	12.01	165.91	116.27	—	690.67	—	231.53	—	—	922.20
Oquawka, Ill.....	274.36	11.50	124.83	139.16	—	549.85	—	—	—	—	549.85
New Boston, Ill.....	625.83	10.47	162.51	159.41	—	958.22	—	116.18	21.62	2.60	1,098.62
Muscatine, Ia.....	198.32	2.29	65.76	266.41	—	532.78	—	847.82	41.56	—	1,422.16
Fairport, Ia.....	352.81	0.18	124.73	137.11	—	614.83	—	190.85	123.01	—	928.69
Andalusia, Ill. (April).....	181.08	2.06	87.24	9.73	—	280.11	—	194.38	—	—	474.49
Andalusia, Ill. (June).....	569.54	38.69	240.22	471.36	—	1,319.81	—	81.22	86.90	—	1,487.93
Andalusia, Ill. (Sept.).....	192.69	20.28	83.30	72.10	138.18	506.55	112.58	854.66	171.25	—	1,645.04
Pleasant Valley, Ia.....	446.76	6.65	112.00	241.24	—	806.65	—	47.22	—	—	853.87
Cordova, Ill.....	317.83	16.86	71.63	169.62	—	575.94	—	189.74	10.50	—	776.18
Fulton, Ill.....	768.51	58.80	109.42	349.91	—	1,286.64	—	105.70	—	—	1,392.34
Sabula, Ia.....	320.10	21.80	43.92	164.06	—	549.88	—	108.24	—	—	658.12
Bellevue, Ia.....	255.55	10.29	51.02	126.84	—	443.70	112.14	140.63	—	—	696.47
Dubuque, Ia.....	426.96	6.30	116.97	151.67	—	701.90	55.84	153.79	—	—	911.53
Total.....	5,326.82	218.18	1,550.46	2,574.89	138.18	9,817.53	280.56	3,261.96	454.84	2.60	13,817.49



Fig. 6.—Commercial fishermen setting a trammel net around a school of carp on the Mississippi River. This type of net was used at several test-net stations.

cal commercial fishermen often proved of little value in locating a good fishing ground and in selecting effective types of fishing gear. The best available fishing sites were selected, rather than particular types of habitat at each station.

Hoop nets and wing nets usually were used after one overnight set. The number of nets used varied with fishing conditions and season.

Trammel-net sets were made at several stations primarily for taking carp and buffalo, fig. 6.

Trammel-net floats were made at stations having smooth bottom and sufficient current to float the nets downstream. These proved to be effective for catching bluegill.

Basket traps, usually baited with cheese or fish scraps, were not very satisfactory since it was necessary to take the traps from the water when moving upstream to a new station. The traps are considered by some fishermen to be effective for catching fish when left in the water over long periods.

Seines could be used only at stations having sufficient beach to permit efficient hauling.

The difficulty of obtaining bait discouraged the use of trotlines.

Two rowboats powered with outboard motors were used in carrying out fishing operations from the *Anax*. When the survey party was traveling between stations these boats were loaded with fishing gear and towed astern of the *Anax*.

Effectiveness of Gear

Each of the various types of gear employed by commercial fishermen is designed for use in a particular type of habitat and for catching a selected kind of fish. The effectiveness and selectivity of gear are mentioned here merely to manifest some of the difficulties encountered in determining the species composition of the fishes in the river, on the basis of catches taken with commercial gear.

The efficiency of hoop nets and wing nets in catching fish decreases during the warm months of the year. The actual poundages and numbers of fish taken at the various stations in the Caruthersville-Dubuque investigation are therefore not indicative necessarily of the abundance of a species at a particular station. Perhaps

Table 6.—Accepted common, scientific, and local names of fishes occurring in Mississippi River test-net or other survey collections between Caruthersville, Missouri, and Dubuque, Iowa, 1944 and 1946.*

ACCEPTED COMMON NAME	SCIENTIFIC NAME	LOCAL NAMES
Shovelnose sturgeon.....	<i>Scaphirhynchus platyrhynchus</i> (Rafinesque).....	Hackback, switchtail, sand sturgeon
Paddlefish.....	<i>Polyodon spathula</i> (Walbaum).....	Spoonbill cat, spoony
Longnose gar.....	<i>Lepisosteus osseus</i> (Linnaeus).....	Garpike, billfish, billy gar
Shortnose gar.....	<i>Lepisosteus platostomus</i> Rafinesque.....	Duckbill gar
Alligator gar.....	<i>Lepisosteus spatula</i> Lacépède.....	Mississippi alligator gar
Bowfin.....	<i>Amia calva</i> Linnaeus.....	Dogfish, grindle, cypress trout, mudfish
Mooneye.....	<i>Hiodon tergisus</i> Le Sueur.....	Toothed herring, white shad
Goldeye.....	<i>Amphiodon alosoides</i> Rafinesque.....	Mooneye
Skipjack.....	<i>Pomolobus chrysochloris</i> Rafinesque.....	Golden shad, river herring, blue herring
Gizzard shad.....	<i>Dorosoma cepedianum</i> (Le Sueur).....	Hickory shad
American eel.....	<i>Anguilla bostoniensis</i> (Le Sueur).....	Freshwater eel
Blue sucker.....	<i>Cycleptus elongatus</i> (Le Sueur).....	Missouri sucker, bluefish, blackhorse, gourdseed sucker
Bigmouth buffalo.....	<i>Megastomatobus cyprinella</i> (Valenciennes).....	Redmouth buffalo, stubnose buffalo, roundhead buffalo, brown buffalo, goarhead, bullhead buffalo, bullmouth buffalo, bullnose buffalo, slough buffalo, trumpet buffalo
Black buffalo.....	<i>Ictiobus niger</i> (Rafinesque).....	Mongrel buffalo, bugler, rooter, reeper, round buffalo, sheepshead buffalo, blue buffalo
Smallmouth buffalo.....	<i>Ictiobus bubalus</i> (Rafinesque).....	Razorback buffalo, roachback buffalo, humpback buffalo, channel buffalo, liner buffalo, quillback buffalo
Quillback.....	<i>Carpiodes cyprinus</i> (Le Sueur).....	Silver carp, carpsucker, coldwater carp
River carpsucker.....	<i>Carpiodes carpio</i> (Rafinesque).....	Silver carp, carpsucker
Highfin sucker.....	<i>Carpiodes velifer</i> (Rafinesque).....	Silver carp, river carp, carpsucker
White sucker.....	<i>Catostomus commersonnii</i> (Lacépède).....	Common sucker, fine-scaled sucker
Spotted sucker.....	<i>Minytrema melanops</i> (Rafinesque).....	Striped sucker
Silver redhorse.....	<i>Moxostoma anisurum</i> (Rafinesque).....	Silver mullet
Northern redhorse.....	<i>Moxostoma aureolum</i> (Le Sueur).....	Des Moines plunger, mullet, common redhorse

Golden shiner	<i>Notemigonus cryoleucas</i> (Mitchill)	American bream, roach
Channel catfish	<i>Ictalurus lucasii</i> (Walbaum)	Fiddler, catfish, channel cat, spotted cat
Blue catfish	<i>Ictalurus furcatus</i> (Le Sueur)	Fulton cat, Mississippi cat, chuckhead cat, coal boater
Yellow bullhead	<i>Ameiurus natalis</i> (Le Sueur)	Yellow-bellied cat, greaser
Brown bullhead	<i>Ameiurus nebulosus</i> (Le Sueur)	Speckled bullhead
Black bullhead	<i>Ameiurus melas</i> (Rafinesque)	Bullhead
Flathead catfish	<i>Pylodictis olivaris</i> (Rafinesque)	Hoosier, goujon, shovelnose cat, mudcat, yellow cat, Johnny cat, Morgan cat, flat belly
Pike	<i>Esox lucius</i> Linnaeus	Pickeral, great northern pike, northern pike, northern
Grass pickerel	<i>Esox vermiculatus</i> Le Sueur	Little pickerel, grass pike, mud pickerel
Yellow pikeperch	<i>Stizostedion vitreum vitreum</i> (Mitchill)	Walleye, jack, jack salmon
Sauger	<i>Stizostedion canadense</i> (Smith)	Sandpike, jack salmon
Smallmouth black bass	<i>Micropterus dolomieu</i> Lacépède	Smallmouth
Spotted black bass	<i>Micropterus punctulatus</i> (Rafinesque)	Kentucky bass
Largemouth black bass	<i>Micropterus salmoides</i> (Lacépède)	Black bass, bigmouth bass, line side, green bass, green trout
Green sunfish	<i>Lepomis cyanellus</i> Rafinesque	Black perch
Organgespotted sunfish	<i>Lepomis humilis</i> (Girard)	
Bluegill	<i>Lepomis macrochirus</i> Rafinesque	Bream, sunfish
Warmouth	<i>Chaenobryttus coronarius</i> (Bartram)	Goggle-eye, warmouth bass
Pier	<i>Centrarchus macropterus</i> (Lacépède)	Round sunfish, longfinned sunfish, round bass
White crappie	<i>Pomoxis annularis</i> Rafinesque	Crappie, newlight
Black crappie	<i>Pomoxis nigro-maculatus</i> (Le Sueur)	Calico bass, strawberry bass
White bass	<i>Lepibema chrysops</i> (Rafinesque)	Silver bass, striped bass, streaker
Yellow bass	<i>Morone interrupta</i> Gill	Streaker, barfish
Freshwater drum	<i>Uta limosa</i> gramineus Rafinesque	White perch, perch, sheephead, gaspergon, grunting perch, croaker

* Because of the pressure of field work, most of the fish handled in the test net collections could be classified only to species. Some, however, could be classified further, and the following subspecies are believed to have been represented in the sampling: *Lepomis gibbosus oxyrinus* Rafinesque, northern longnose gar; *Carpiodes carpio carpio* (Rafinesque), northern carp sucker, *Catostomus commersonnii commersonnii* (Lacépède), white sucker; *Notemigonus cryoleucas aeneus* (Rafinesque), northern golden shiner; *Ictalurus lucasii punctatus* (Rafinesque), southern channel catfish; *Ictalurus furcatus furcatus* (Valenciennes), blue catfish; *Ameiurus natalis marmoratus* (Hillbrook), northern brown bullhead; *Ameiurus melas melas* (Rafinesque), northern black bullhead; *Stizostedion canadense canadense* (Smith), eastern sauger; *Micropterus dolomieu dolomieu* Lacépède, northern smallmouth black bass; *Micropterus punctulatus punctulatus* (Rafinesque), northern spotted black bass; *Lepomis macrochirus macrochirus* Rafinesque, common bluegill. Accepted common and scientific names in the table are from Special Bulletin No. 1 of the American Fisheries Society (1948); most subspecific names in the footnote are from Hulds & Lauder (1947).

only if the efficiency of the nets remained constant throughout the year could a just comparison on a pounds-per-net-day basis be made of the catches at various stations.

The seasonal activities and habitat preferences of various fishes complicate sampling with commercial gear. For example, a type of gear that is very effective for catching a certain species in the spring may be ineffective later in the year.

Throughout this investigation various types of gear were used and every effort was made to obtain a large catch at each station. To obtain large catches during the summer, it was usually necessary to increase the amount of fishing effort, table 1.

The composition of the catch at each station in the Caruthersville-Dubuque section of the Mississippi is presented in Appendix B. The data do not permit further valid statistical treatment. Difficulties encountered in netting preclude the assumption that a random sample was obtained.

Classification of Fishes

Among fishermen, the species of fishes found in the Mississippi River are known by many names. These names are often local in use and are of little value to fishermen or scientists working in another area. Among scientists, also, confusion of names exists. In an attempt to bring order out of the confusion of common and scientific names, the American Fisheries Society (1948) issued a special publication listing the generally accepted common and scientific names of the better-known fishes of the United States and Canada. In the present paper, most of the names—both common and scientific—adhere to those given in this special publication. The accepted common and scientific names and the widely used vernacular names of fishes taken in the Caruthersville-Dubuque survey are included in table 6.

The Mississippi River fishes of direct importance to man are treated as either commercial or sport fishes. It will be noted that certain species, particularly bullheads and other catfishes, included with the commercial fishes are also of importance to the sport fishery.

In the MR-C section of the river the mooneye (*Hiodon tergisus*) and the gold-eye (*Amphiodon alosoides*) are of little

importance commercially, whereas in parts of the D-MR section they are of some economic value. The data pertaining to these fishes are included in 1944 with the forage fishes and in 1946 with the commercial fishes. In tables where data are presented for both years, these fishes are considered as forage fishes.

The forage fishes may be defined usually as those of value only as food for other fishes. This group is composed largely of minnows (Cyprinidae); however, a member of the herring family, the gizzard shad (*Dorosoma cepedianum*), forms an important part of forage in the Mississippi River.

The gars (*Lepisosteus* spp.) and the bowfin (*Amia calva*) are not considered of sufficient commercial value to be included with the commercial fishes. They are regarded as a group known to prey upon other fishes and are presented as predators. Many of the other fishes, such as catfishes (Ameiuridae), black basses (*Micropterus* spp.), white bass (*Lepomis chrysops*), crappies (*Pomoxis* spp.), sauger (*Stizostedion canadense*), yellow pikeperch (*Stizostedion vitreum vitreum*), and pike (*Esox lucius*), are predatory fishes; however, superficially at least they are of more importance to man as commercial or sport fishes.

COMMERCIAL FISHES

Commercial fishes amounted to 76.4 per cent by weight of all fishes caught in the Caruthersville-Dubuque test-net survey of the Mississippi River. In 1946, the Mississippi River catch reported by commercial fishermen of Missouri, Iowa, and Illinois had a market value, based on local prices, of \$396,824. If all the commercial fishermen of these states had reported all their Mississippi River catches and if the calculations had been based on prices actually received, rather than on local prices, the calculated value of the catch would have been higher. Many small operators who sold their fish locally did not report their catches, and many large operators shipped their fish to distant markets where they received prices higher than those prevailing in the local markets.

The species composition of the commercial catch in the Caruthersville-Dubuque

Table 7.—Commercial catches of some species of fishes from the Mississippi River for the years 1894, 1899, 1931, and 1946 as recorded for the states of Illinois, Missouri, and Iowa.* For purposes of comparison, catches are further expressed as per cents of the 1899 catch.

YEAR AND STATE	CARP		BUFFALO		CATFISH AND BULLHEAD		FRESHWATER DRUM		SHOVELNOSE STURGEON		LAKE STURGEON		PADDLEFISH		EEL	
	Weight in Pounds	Per Cent of 1899 Catch	Weight in Pounds	Per Cent of 1899 Catch	Weight in Pounds	Per Cent of 1899 Catch	Weight in Pounds	Per Cent of 1899 Catch	Weight in Pounds	Per Cent of 1899 Catch	Weight in Pounds	Per Cent of 1899 Catch	Weight in Pounds	Per Cent of 1899 Catch	Weight in Pounds	Per Cent of 1899 Catch
1894																
Illinois.....	235,848	16.30	1,937,596	122.87	806,120	172.10	421,722	166.23	40,297	38.51	37,366	120.64	117,446	79.24	17,781	110.79
Missouri.....	47,289	11.31	1,178,745	154.41	546,986	157.42	163,665	143.25	30,189	39.82	37,877	521.08	106,976	100.38	6,241	191.68
Iowa.....	163,309	16.61	1,064,166	129.10	849,001	126.92	658,364	215.69	7,572	108.02	43,312	135.06	45,201	219.00	19,250	192.92
1899																
Illinois.....	1,446,698	100.00	1,576,998	100.00	468,403	100.00	253,696	100.00	104,644	100.00	30,974	100.00	148,216	100.00	16,050	100.00
Missouri.....	417,980	100.00	763,386	100.00	347,479	100.00	114,255	100.00	75,810	100.00	7,269	100.00	106,576	100.00	3,256	100.00
Iowa.....	983,305	100.00	824,291	100.00	668,935	100.00	305,230	100.00	7,010	100.00	32,068	100.00	20,640	100.00	9,978	100.00
1931																
Illinois.....	562,999	38.92	252,632	16.02	296,374	63.27	105,982	41.78	25,366	24.24	0	0	23,485	15.85	835	5.20
Missouri.....	265,005	63.40	112,140	14.69	†	—	26,845	23.50	14,239	18.78	0	0	37,388	35.08	1,055	32.40
Iowa.....	1,506,654	153.22	738,015	89.53	446,790	66.79	329,049	107.80	17,500	249.64	0	0	9,400	45.54	335	3.26
1946																
Illinois.....	792,250	54.76	398,515	25.27	259,686	55.44	173,429	68.36	12,493	11.94	0	0	26,853	18.12	†	—
Missouri.....	217,909	52.13	83,255	10.91	†	—	55,432	48.52	4,361	5.75	0	0	10,213	9.58	566	17.38
Iowa.....	800,332	81.39	628,549	76.25	342,345	51.18	244,960	80.25	13,327	190.11	0	0	**	—	1,525	15.28

* 1894 (Smith 1898); 1899 (Townsend 1902); 1931 (Fiedler 1933); 1946 (unpublished records of the Illinois, Iowa, and Missouri conservation departments). The 1946 figures are based on yield reports submitted by commercial fishermen to their respective state conservation departments. The Iowa figure includes reports from more than 90 per cent of the state's licensed commercial fishermen, whereas the Illinois figure includes reports from only 26.5 per cent and the Missouri figure 35.5 per cent of the commercial fishermen of the respective states. Although the number of returns from the latter two states is small, it is believed that the statistics include most of the large operators and represent a large part of the actual catch.

† No data.

** Illegal to take.

Table 8.—Commercial catches in pounds of the more important fishes from the Mississippi River at Lake Keokuk, or Pool No. 19 (Illinois and Iowa), and between the northern border of Illinois and Lake Keokuk (Illinois) for various years for which data are available, 1914–1946.*

YEAR	LAKE KEOKUK (Illinois and Iowa)						NORTHERN ILLINOIS BORDER TO LAKE KEOKUK (Illinois)					
	Carp	Buffalo-fishes	Catfishes and Bullheads	Freshwater Drum	Paddlefish	Shovelnose Sturgeon	Carp	Buffalo-fishes	Catfishes and Bullheads	Freshwater Drum	Paddlefish	Shovelnose Sturgeon
1914.....	302,365	249,900	71,535	26,860	0	0	—	—	—	—	—	—
1917.....	762,259	696,543	109,904	160,554	927	0	—	—	—	—	—	—
1922.....	276,431	113,946	183,919	65,040	27,405	600	—	—	—	—	—	—
1927.....	291,199	67,872	140,343	27,538	1,249	0	—	—	—	—	—	—
1931.....	170,149	112,365	119,670	72,829	7,100	300	—	—	—	—	—	—
1932.....	209,750	82,500	87,500	91,750	1,300	1,100	456,500	183,100	148,700	139,500	500	2,400
1933.....	213,000	75,800	88,500	87,500	0	875	351,600	166,800	107,950	131,500	500	10,200
1934.....	352,500	84,600	108,500	133,500	14,400	0	396,800	183,300	162,600	199,700	2,100	7,000
1935.....	386,200	102,500	120,500	119,600	10,700	225	373,000	191,000	155,800	129,900	2,250	0
1936.....	480,200	131,000	184,800	127,400	4,400	0	623,200	334,700	237,700	167,800	2,100	1,000
1937.....	527,000	195,000	170,500	166,300	13,200	1,300	356,000	177,500	146,900	134,500	3,700	0
1938.....	348,700	112,400	70,200	77,300	2,400	0	359,400	197,200	94,100	104,100	0	0
1946.....	247,506	92,774	95,703	68,422	397	2,265	239,647	151,286	69,206	47,371	3,753	3,172

* 1914, 1917, 1922, and 1927 (Coker 1929); 1931 (Fiedler 1933); 1932 (Fiedler, Manning, & Johnson 1934); 1933 (Fiedler 1935); 1934 (Fiedler 1935); 1935 (Fiedler 1938a); 1936 (Fiedler 1938b); 1937 (Fiedler 1940); 1938 (Fiedler 1941); and 1946 (unpublished records of the Illinois and Iowa conservation departments, as explained in first footnote to table 7).

Table 9.—Species composition of Mississippi River commercial catches based on per cents of total weights published in commercial fishery reports for Illinois and Missouri for 1894, 1899, 1931, and 1946.*

YEAR AND STATE	PER CENT CARP	PER CENT BUFFALO- FISHES	PER CENT CATFISHES AND BULLHEADS	PER CENT FRESH- WATER DRUM	PER CENT GAME FISHES	PER CENT SILVER- SALMON	PER CENT PADDLE- FISH	PER CENT PIKE	PER CENT YELLOW PIKE- PERCH AND SAUGER	PER CENT MISCEL- LANEOUS	TOTAL WEIGHT IN POUNDS
<i>1894</i>											
Illinois.....	5.93	48.70	20.26	10.60	2.53	1.95	2.95	0.25	0.45	6.39	3,978,731
Missouri.....	2.04	50.90	23.62	7.07	1.37	2.94	4.62	0.01	0.52	6.92	2,315,996
<i>1899</i>											
Illinois.....	33.43	36.44	10.82	5.86	2.78	3.13	3.42	0.13	0.35	3.64	4,327,766
Missouri.....	21.63	39.51	17.98	5.91	1.01	4.30	5.52	0.00	0.23	3.91	1,932,296
<i>1931</i>											
Illinois.....	44.02	19.75	23.17	8.29	Illegal†	1.98	1.84	Illegal	Illegal	0.94	1,278,928
Missouri.....	49.08	20.77	9.81	4.97	Illegal	2.64	6.92	Illegal	Illegal	5.84	539,997
<i>1946</i>											
Illinois.....	46.19	23.24	15.14	10.11	Illegal	0.73	1.57	Illegal	Illegal	3.03	1,715,133
Missouri.....	49.14	18.78	13.03	12.50	Illegal	0.98	2.30	Illegal	Illegal	3.26	443,423

* 1894 (Smith 1899), 1899 (Friedler 1902), 1931 (Fiedler 1933), and 1946 (unpublished reports of the Illinois, Iowa, and Missouri conservation departments, as explained in first footnote to table 7).

† The 1946 Illinois catch does not include the eel.

‡ Two hundred pounds of white bass reported by Fiedler (1933) are included in total weight figure for Illinois, 1931.

section of the Mississippi has changed considerably during the past 50 years. Commercial catch statistics relative to that section of the river bordering Missouri, Illinois, and Iowa are given in tables 7, 8, and 9. In 1894, carp (*Cyprinus carpio*) represented only 5.9 per cent by weight of the Mississippi River commercial catch by Illinois fishermen, table 9, whereas in 1946 carp amounted to 46.2 per cent of this catch. In 1894 the buffalofishes (Catostomidae) dominated the catch, as does the carp today. In table 7 the 1899 commercial report is used as a basis for interpreting trends in the catch of several commercial fishes. From these data it is apparent that the carp, buffalofishes, catfishes, and freshwater drum (*Aplodinotus grunniens*) have not been so greatly affected by man's modification of the river as have the paddlefish (*Polyodon spathula*), lake sturgeon (*Acipenser fulvescens*), and American eel (*Anguilla bostoniensis*).

The various species of buffalofishes and catfishes are difficult to distinguish, and commercial fishermen usually refer to them by local names, which sometimes are meaningless to fish technicians. This practice has necessitated that workers compiling statistics of commercial catches of Mississippi River fishes rely on the inclusive groupings of these fishes rather than on individual species. These fishes are discussed here on the basis of the inclusive groupings and their constituent species as determined during the survey.

Sturgeons

ACIPENSERIDAE

This family of fishes has a wide distribution in the northern parts of Asia, Europe, and North America. Some members are marine and ascend fresh-water rivers to spawn, whereas others are wholly confined to fresh water. Only three species of the seven known to occur in North American waters are found in the Caruthersville-Dubuque section of the Mississippi River.

The shovelnose sturgeon (*Scaphirhynchus platyrhynchus*) is now the only sturgeon of any commercial importance in the river. In 1946 a total of 30,181 pounds of this fish were reported as taken com-

mercially from the Mississippi by Illinois, Iowa, and Missouri fishermen. As shown in table 7, the Mississippi River commercial catch of this sturgeon reported for Illinois and Missouri in 1946 was only 11.9 and 5.8 per cent, respectively, of the amounts reported for these states in 1899. The 1946 catch reported for Iowa was 190.1 per cent of the amount of the 1899 catch; however, it will be noted in table 7 that the 1899 catch for Iowa was very low as compared with that for Illinois and Missouri. From these statistics it must be concluded that the shovelnose sturgeon is much less abundant than it was prior to 1900.

It would be impossible to ascertain all of the contributing factors causing the decline of this fish. As determined by trammel netting, the shovelnose sturgeon is found most commonly over a sand or gravel bottom in the presence of some current. This type of habitat in the D-MR section of the Mississippi has been reduced by canalization and siltation. Several stomachs of the shovelnose sturgeon were examined from specimens taken at Andalusia and were found to contain mayfly nymphs of the genus *Hexagenia*. The siltation has reduced suitable habitats for many of the insect nymphs and larvae which form a part of the sturgeon diet. According to Coker (1930:152), fish of this species were once considered a nuisance in the Mississippi and many of them were destroyed by fishermen when taken in nets.

Very little is known regarding the habits of the shovelnose sturgeon, and a lack of knowledge of this fish has been a handicap in formulating legislation to protect it.

In the Caruthersville-Dubuque survey all of the catches of shovelnose sturgeon, with the exception of one, were taken by trammel-net floating. As tables 2 and 3 indicate, no trammel-net floating was done below the mouth of the Missouri River, which apparently explains the absence of the shovelnose sturgeon from catches in the MR-C section. That this sturgeon still is present in this section is evidenced by commercial reports and by specimens seen during the survey. At Hickman, Kentucky, in 1944, fishermen were seen catching shovelnose sturgeons on trotlines baited with worms. In the section of the

Table 10.—Length-frequency distribution, average lengths,* and average weights of shovelnose sturgeons taken from the Mississippi River at Burlington, Iowa, and Andalusia, Illinois, in 1946.

STANDARD LENGTH IN INCHES	BURLINGTON, IOWA† APRIL 12, 1946	ANDALUSIA, ILL. APRIL, 1946	ANDALUSIA, ILL. JUNE, 1946	ANDALUSIA, ILL. SEPTEMBER, 1946	TOTAL
13.8-14.7.....	—	—	1	—	1
14.8-15.7.....	—	—	—	1	1
15.8-16.7.....	—	1	—	6	7
16.8-17.7.....	—	1	—	5	6
17.8-18.7.....	—	5	—	1	6
18.8-19.7.....	2	11	3	4	20
19.8-20.7.....	2	7	8	5	22
20.8-21.7.....	3	18	6	9	36
21.8-22.7.....	—	18	7	12	37
22.8-23.7.....	3	22	11	6	42
23.8-24.7.....	9	18	5	13	45
24.8-25.7.....	2	18	3	7	30
25.8-26.7.....	4	11	4	3	22
26.8-27.7.....	2	7	2	1	12
27.8-28.7.....	1	5	3	3	12
28.8-29.7.....	—	1	2	—	3
29.8-30.7.....	—	1	1	1	3
30.8-31.7.....	—	2	—	—	2
31.8-32.7.....	2	—	—	—	2
32.8-33.7.....	—	1	—	—	1
Total number.....	30	147	56	77	310
Average length.....	24.5	23.4	23.3	22.2	23.2
Average weight in pounds.....	1.69	1.34	1.45	1.07	1.33

* Length from tip of snout to base of caudal filament.

† The specimens were taken near Burlington by J. O. Kurre, a commercial fisherman.

river between Burlington and Dubuque the shovelnose sturgeon amounted to 2.6 per cent by weight of the total catch. This figure indicates that the species is not scarce in this section of the river and that it is able to maintain itself in spite of canalization. The commercial take of this species for intermittent years, 1914 through 1946, at Lake Keokuk (Pool No. 19) and, 1932 through 1946, in that part of the river between Lake Keokuk and the northern border of Illinois is given in table 8. For the years included in this table the shovelnose sturgeon formed only a small portion of the commercial catch.

Sex determinations were made of 307 of the 310 shovelnose sturgeons caught in 1946. In April the males predominated in the collections taken in the channel of the river by trammel-net floating. During this month males made up 93 per cent of the catch of this species at Burlington and 99 per cent at Andalusia. At Andalusia in June males represented only 41 per cent of the catch and in September 57

per cent. The predominance of males in the channel in April indicates that the females seek another habitat during this season, returning to the channel by June. According to Harry E. Finley, a commercial fisherman at Andalusia, female shovelnose sturgeons are seldom taken by commercial fishermen during April and May, which he believes are the months of the spawning season. During this period, in his opinion, the females seek cover and consequently do not occur in the open water of the channel where trammel nets are normally drifted.

Observations on size and condition of gonads of the shovelnose sturgeon indicate that the males reach maturity at lengths of 19.5 to 22 inches (standard length, which is length from tip of snout to base of caudal filament); the smallest mature female examined was 25 inches in length. The length-frequency distribution of the fishes taken at Burlington and Andalusia, table 10, indicates that trammel nets catch many sturgeons less than 25 inches in

length. The adoption of a legal minimum length of 25 inches would afford some protection to immature shovelnose sturgeons.

The average weight of shovelnose sturgeons taken during the survey was only 1.3 pounds (excluding the Burlington catch). Fish of this species are not known to attain such great weights as the lake sturgeon.

The fishery statistics for 1894 and 1899, table 7, indicate that the lake sturgeon (*Acipenser fulvescens*) was once rather common in the Mississippi River. Forbes & Richardson (1920: 25), writing in 1908 or before, stated that this species was steadily decreasing and only rarely was taken in the Mississippi on the borders of Illinois. No lake sturgeon was caught in the test nets in 1944 or 1946. A lake sturgeon weighing 32 pounds was taken May 6, 1946, in a hoop net of a commercial fisherman at New Boston, Illinois. This was the only specimen of this species observed by the work party during the 2 years of the field investigation. The lake sturgeon is now taken only occasionally by commercial fishermen of the area.

More than 45 years ago, Forbes & Richardson (1905:38) described as *Parascaphirhynchus albus* a species of sturgeon taken from the Mississippi River near Alton and Grafton. They gave it the common name white sturgeon, the term by which it was known to fishermen of the locality. Later, Forbes & Richardson (1920: 29) stated that this sturgeon was known to them only from the Mississippi River at Grafton and Alton, where it was rare, but that it was said by a commercial fisherman to be somewhat commoner in the lower part of the Missouri.

In 1944 one specimen of this species was procured from an angler fishing in the Mississippi River just above the mouth of the Missouri. It weighed only 0.12 pound. According to fishermen in the Alton area, fish of this species are taken occasionally by them along with the shovelnose sturgeon. These fish are not known from the Mississippi other than near its confluence with the Missouri. The specimen mentioned above was the only one of this species observed between Caruthersville and Dubuque.

This specimen was submitted for identification to Dr. Reeve M. Bailey of the

University of Michigan Museum of Zoology who (personal communication) determined it as *Scaphirhynchus albus* (Forbes & Richardson). The species is at present without a recognized common name. The term white sturgeon is recognized (American Fisheries Society 1948) as the common name for *Acipenser transmontanus*, with which the species of the Mississippi River should not be confused. To Mississippi River fishermen *S. albus* is known as the white hackleback and the white shovelnose, as well as the white sturgeon. Dr. Bailey (personal communication) recently suggested the vernacular name pallid sturgeon for *S. albus*.

Paddlefish

POLYODONTIDAE

This interesting fish was recorded by the first white expedition that reached the Mississippi River. Nuttall (1821:254) mentioned that at Pacaha members of the De Soto expedition, fishing with nets, included in their catch "the Pele-fish, destitute of scales, and with the upper jaw extended in front a foot in length, in the form of a peel or spatula." Jefferson (1801:12) included in his list of Mississippi River fishes a spatula-fish of 50 pounds weight.

The paddlefish, which is often referred to as the spoonbill cat by commercial fishermen, has long attracted the attention of zoologists. The skeleton of this primitive fish is largely of cartilage, and the external appearance of the fish is quite sharklike. The paddlefish family (Polyodontidae) is composed of only two genera, each containing a single species, one found in China, the other in North America (Forbes & Richardson 1920: 15). The North American species is limited in distribution to the Mississippi basin and other tributaries of the Gulf of Mexico (Coker 1930: 142). According to Eddy & Surber (1947: 74), the paddlefish once ranged in the quiet waters of the Mississippi River from Minneapolis to the Gulf; it is now much more abundant in the southern part of its range than farther north. In the Caruthersville-Dubuque survey the paddlefish was not taken above Canton; however, in 1946 a commercial catch of 1,204 pounds was taken in one seine haul near

New Boston. Many of these specimens were examined by the survey party and the data and gonad material were assigned to Dr. R. Weldon Larimore of the Illinois Natural History Survey for histological study. Paddlefish were caught at 40 per cent of the stations below the mouth of the Missouri River and 42 per cent of the stations between the mouth of the Missouri and Warsaw. Fish of this species were usually taken with a seine, and the average weight of specimens was 2.17 pounds.

On August 19, 1944, at the Cincinnati Landing station, a large school of paddlefish was sighted by the survey crew at about 5 P. M. These fish appeared to be large and apparently were feeding in the shallow water over sand bottom. They were swimming so near the surface that the tailfins of the larger ones extended several inches above the water, and, as they swam often in what appeared to be an aimless manner, some of them frequently thrust their paddles above the surface. Plans were immediately made to seine the area; however, before a seine could be obtained a half hour had elapsed and, much to the disappointment of the crew, the large school had completely vanished.

At the Quincy and New Boston stations paddlefish were observed traveling in schools and feeding in shallow water over sand bottom. In the canalized section of the river this type of habitat is largely confined to the upper sections of the pools. In all catches and observations made during the survey the paddlefish was associated with sand bottom.

At the Cape Girardeau station on May 29, 1944, four specimens of a post-larval stage of paddlefish were taken along the sandy shore of an island. The post-larval forms collected by Thompson (1933:31) near Grand Tower, Illinois, in May, 1932, also were taken over a hard sand bottom.

In 1946 the commercial value of paddlefish in the round was 15 cents per pound. About 20 years ago Coker (1930:142) stated that the roe of the paddlefish was sometimes worth more than \$2.00 a pound and that a large female might have considerable value, as its roe might weigh 10 to 15 pounds. Since 1899 the commercial take of paddlefish in the upper

Mississippi has decreased considerably, as shown in tables 7, 8, and 9. This species in the Caruthersville-Dubuque section is becoming relatively scarce. It has been placed on the protected list by the state of Iowa in the hope that its abundance will be increased. If full protection were rendered the paddlefish, it probably would continue to be reduced in numbers by commercial fishermen since this fish often dies after being handled.

American Eel

ANGUILLIDAE

The American eel spawns in the sea. The young eels ascend rivers and streams where they remain for several years. Upon reaching mature size, they return to the sea where they spawn and die.

According to Eddy & Surber (1947:192) the American eel was at one time fairly common up the Mississippi River at least as far as St. Anthony Falls, Minnesota, but it has now become almost extinct in Minnesota and Wisconsin. These writers stated that the dams on the river are undoubtedly responsible for the scarcity of the eel in the upper Mississippi. The commercial reports show a decline in the eel fishery in the Illinois-Iowa-Missouri section of the Mississippi since 1894, table 7. Even in 1894 this fishery was small, the recorded commercial catch amounting to only 43,272 pounds. In 1931 the catch was only 2,215 pounds. In 1946 very few eels were taken commercially in the section of the river adjacent to Missouri. In that year the largest recorded catch was in the canalized Iowa section; no catch data for Illinois were available.

Coker (1930:173) concluded from his studies at Lake Keokuk that the eel must virtually disappear from the Mississippi River and tributaries above the Keokuk dam (Lock and Dam No. 19). He mentioned that the eel had been decreasing steadily for 30 years in the Mississippi and he was unable to attribute the decline to a single cause, particularly since the decline started prior to the construction of the Keokuk Dam, practically completed in 1913.

In the Caruthersville-Dubuque survey, eels were taken at a larger percentage of

the stations above the mouth of the Missouri River than below. In the canalized section of the river between Burlington and Dubuque, eels amounted to 0.1 per cent of the total number of fishes taken; below the mouth of the Missouri, 0.2 per cent. At Dubuque, the uppermost station on the river, three eels were taken weighing a total of 9.1 pounds. At the Hannibal station six eels were caught; this was the largest number taken at a single station. This station was situated in Pool No. 22, which is above four locks and dams. The eel, as evidenced by these catches, moves upstream into the canalized section even though its passage is hindered by a series of locks and dams. On the basis of this investigation, the eel appears not to be common anywhere in the river, and its scarcity is such as to make it of little or no commercial importance.

Suckers and Redhorses

CATOSTOMIDAE

The fishes in this family, other than the carpsuckers, are too scarce to be of much commercial importance in the Caruthersville-Dubuque section of the Mississippi. The carpsuckers (*Carpiodes* spp.) constituted one of the more abundant groups of fishes taken during the survey. They were taken at all stations, usually in considerable numbers. Because of the difficulties encountered in the separation of the species of carpsuckers, no attempt was made to distinguish the species afield. Names of the three species identified from the collections are listed in table 6. Carpsuckers amounted to 7.2 per cent of the total weight of the 1944 catch between Caruthersville and Warsaw and 14.2 per cent of the total weight of the 1946 catch between Burlington and Dubuque, Appendix B.

At Keokuk, Coker (1930:184) found the river carpsucker (*Carpiodes carpio*) the only carpsucker constituting a notable fishery product. The commercial fishery statistics pertaining to the 1946 Mississippi River catch of Illinois, Iowa, and Missouri indicate that in total weight the carpsuckers ranked fifth. The catch of carpsuckers in the test-netting survey indicates that these fish form a larger percentage of the catch than is shown by the

commercial statistics. In the canalized section of the river between Burlington and Dubuque, the three species of carpsuckers ranked second by weight in the test-net catches, and in the lower section of the river they ranked third. Appendix B. During these 2 years the average weight of carpsuckers was 1.24 pounds. According to Coker (1930:185) carpsuckers of substantial size (above 4 pounds) are considered of commercial value, "usually selling as No. 1 fish, some others selling as No. 2 fish, and still others being thrown away." Because of this large size requirement, and because the flesh of carpsuckers is favorless and soft (Forbes & Richardson 1920:77) and is said not to keep well in warm weather (Coker 1930:184), many of the carpsuckers actually taken are not marketed and therefore do not appear in the commercial reports. Methods of processing for better utilization of the carpsuckers are sorely needed on the Mississippi as well as on other large rivers in the central states.

Forbes & Richardson (1920:66), about 50 years ago, found that the blue sucker (*Cycleptus elongatus*) was confined to the Ohio and Mississippi rivers and some of its tributaries. In the Mississippi they rarely found this sucker above Quincy at the time of their survey. However, several years later Greene (1935:57) mentioned that the blue sucker was reported to be common in the river near Lansing, Iowa, which is about 337 miles above Quincy, and Coker (1930:182) cited "oral reports of fishermen at many points on the Mississippi, as far north as Wisconsin, that until 10 or 15 years ago there were important spring runs and lesser fall runs of blue suckers." In the spring, blue suckers formerly were caught quite easily by commercial fishermen. These catches were made in the swifter parts of the river. By 1926, however, according to Coker (1930:183), commercial fishermen held an almost unanimous opinion that the blue sucker had virtually disappeared from the upper river. That same year Coker encountered practically no fishermen in the Keokuk area who had seen more than two or three blue suckers a year.

In the Caruthersville-Dubuque survey the blue sucker was taken infrequently. No adult blue sucker was caught in the

MR-C section of the river, although at the Cairo station 28 small blue suckers were taken with a minnow seine. Forbes & Richardson (1920:66) noted in the early part of this century that the blue sucker frequently was taken in the Cairo area during the spring. This species was not abundant enough at the time of the survey to be of any commercial importance in the Cairo area, even though it still occurred there.

On April 11, 1951, Herbert J. Fisher of the Missouri Conservation Commission and the junior author examined five blue suckers at Bennett Brothers' fish market at Ste. Genevieve, Missouri. The fishermen had caught about 100 pounds of this species in hoop nets on April 10 and 11.

All specimens of this sucker taken by the survey party in the D-MR section of the river were caught at or above the Cincinnati Landing station. At this station in August, 1944, an adult blue sucker weighing 2.8 pounds was caught in a test net set in a small slough. The flow into this slough passed over a rock wing-dam at the head of an island. The slough was approximately 150 yards in width, and the current was moderately swift over a sand bottom. At the Canton station two blue suckers weighing in aggregate 3.62 pounds were taken in test nets. Only five blue suckers were taken in the 1946 collections between Burlington and Dubuque, Appendix B, table 2. The scarcity of the blue sucker in the Caruthersville-Dubuque section of the river as shown by the test-net collections confirms the pessimistic opinions of commercial fishermen concerning the present status of this fish.

The removal of the Le Claire and Keokuk rapids in the river and construction of the Keokuk Dam have been considered as factors contributing to the decline of the blue sucker population in the D-MR section of the river. According to Coker (1930:184, 187), however, the blue sucker also declined in the MR-C section of the river—indicating that some other factor or factors contributed to its decline.

The northern redhorse (*Moxostoma aureolum*) was netted more frequently than the silver redhorse (*Moxostoma anisurum*), the only other species of redhorse taken in the test-net survey. It appeared

in the collection at only one station in the MR-C section of the river, whereas it was taken at all stations above Burlington in the D-MR section. The largest catches of the northern redhorse were made at the Bellevue station, where they amounted to 15.9 per cent of the total weight of all fish taken there.

In the Burlington-Dubuque section the total weight of the northern redhorse catch was 1.5 per cent of the total catch for the section. In the section between Burlington and the mouth of the Missouri, the northern redhorse amounted to only 0.27 per cent of the total weight of the catch there. These data indicate that the northern redhorse is more abundant in the river above Burlington than below.

The commercial fishery statistics for suckers in the Mississippi basin show a sharp decline since 1899 (Coker 1930:187). The various species of redhorses and suckers are now too scarce in the Caruthersville-Dubuque section of the river to be of commercial importance.

Buffalofishes

CATOSTOMIDAE

Three species of buffalofishes occur in the Caruthersville-Dubuque section of the Mississippi River. In aggregate, these fishes now rank second to carp in the Mississippi River commercial fishery catch of Illinois, Iowa, and Missouri. Prior to the appearance of the carp, the buffalofishes comprised the largest part of the commercial catch. In 1894 the buffalofishes constituted 48.7 per cent of the weight of the Illinois catch in the Mississippi River and 50.9 per cent of the Missouri catch in the Mississippi, table 9. In 1899 the catch of buffalofishes still held a weight advantage over the catch of carp, which by that year were becoming very abundant in the river.

As shown in table 8, the catch of carp at Lake Keokuk (Pool No. 19) in 1914 exceeded that of buffalofishes by more than 50,000 pounds.

At Lake Keokuk the carp made its greatest gains over the buffalofishes between 1922 and 1927. By 1931 the buffalofishes represented only 19.8 per cent of the weight of the Mississippi River catch by Illinois commercial fishermen and 20.8 per

cent of that by Missouri fishermen, table 9. Commercial catches of buffalofishes in that part of the Mississippi bordering Illinois, Iowa, and Missouri have been much smaller in most recent years than in years previous to 1900; however, the decrease in catch, as shown by 1946 figures in table 7, has not been so great as to cause alarm. Commercial reports indicate that the buffalofish catches in Iowa have remained high and have decreased only slightly below the 1899 catch. In 1950 the Mississippi River catch of buffalofishes by commercial fishermen of Illinois was larger than the catch of carp and amounted to 36.6 per cent of the total commercial catch from the Mississippi by these fishermen.

During the past 50 years extensive levee and drainage districts have been developed in the MR-C section of the river—more extensive than in the D-MR section. The development in the lower section has resulted in a scarcity of backwaters and sloughs attached to this section. The buffalofishes are known to use backwaters and sloughs for spawning grounds, and perhaps the reduction of such areas in the lower section accounts for much of the decrease in the buffalo fishery there during the past half century. At Lake Keokuk (Pool No. 19) Coker (1930:194) noted an upward trend in the commercial take of buffalofishes in 1917 and a discouraging decline in 1922. Between these years, Coker writes, extensive areas evidently suitable for spawning and nursery purposes were reclaimed for farming. In table 8 the commercial catches from Lake Keokuk are given for several years. The catches of buffalofishes from this impoundment have never recovered since connecting shallow waters were reclaimed for agricultural purposes.

The buffalofishes ranked fourth in total weight among the commercial fishes taken in the test-net collections, fig. 7, rather than second as might be expected from the commercial fishery statistics. This difference in rank was due probably to fishing effort and type of gear employed and to the inclusion in survey data of all carp-suckers taken during the survey; carpsuckers are a group of fishes not invariably reported by commercial fishermen.

The average weight of buffalofishes taken between Caruthersville and Warsaw

in 1944 was 1.65 pounds; between Burlington and Dubuque in 1946 it was 1.78 pounds. The over-all average was 1.72 pounds.

On a numerical basis the buffalofishes ranked fifth among the commercial fishes taken in the test-net collections, fig. 7.

In the commercial statistics, for reasons previously discussed, the catches of the three species of buffalofishes are presented in aggregate. An attempt has been made to appraise the relative abundance of the three species and their distribution in the MR-C and D-MR sections of the river, fig. 8. Such information should be of value in the management of the buffalo fishery. The meager information concerning these fishes indicates the existence of certain differences in the habits of the three species.

The black buffalo (*Ictiobus niger*) was taken in greater numbers in the collections from the MR-C section than in those from the D-MR section of the river, fig. 8. Coker (1930:191) noted that the black buffalo (bugler) was chiefly southern in distribution and that at the time of his study it was not abundant in the river above Muscatine. He found that it appeared "rather prominently in the region of New Boston and southward," and just below Keokuk it seemed to rank in abundance with the smallmouth buffalo or roachback (*Ictiobus bubalus*).

At the Warsaw station, which was below Keokuk, the buffalo test-net catch in 1944 was predominantly smallmouth, Appendix B, table 1. Here 59 specimens of the smallmouth buffalo were taken in contrast to 1 specimen of the black buffalo and 3 of the bigmouth buffalo (*Megastomatobus cyprinella*). At Caruthersville no black buffaloes were taken in the survey nets; however, according to a Mr. Boyer, a local commercial fisherman, this species and the other buffalofishes usually are taken in catches in about equal numbers. One black buffalo weighing 19.5 pounds was examined from a commercial fisherman's catch at Caruthersville. The average weight of the black buffaloes taken in the survey was 4.06 pounds, an average much greater than that of the other species of buffalofishes.

The bigmouth buffalo appeared to be more abundant than the black buffalo. However, the average weight of the big-

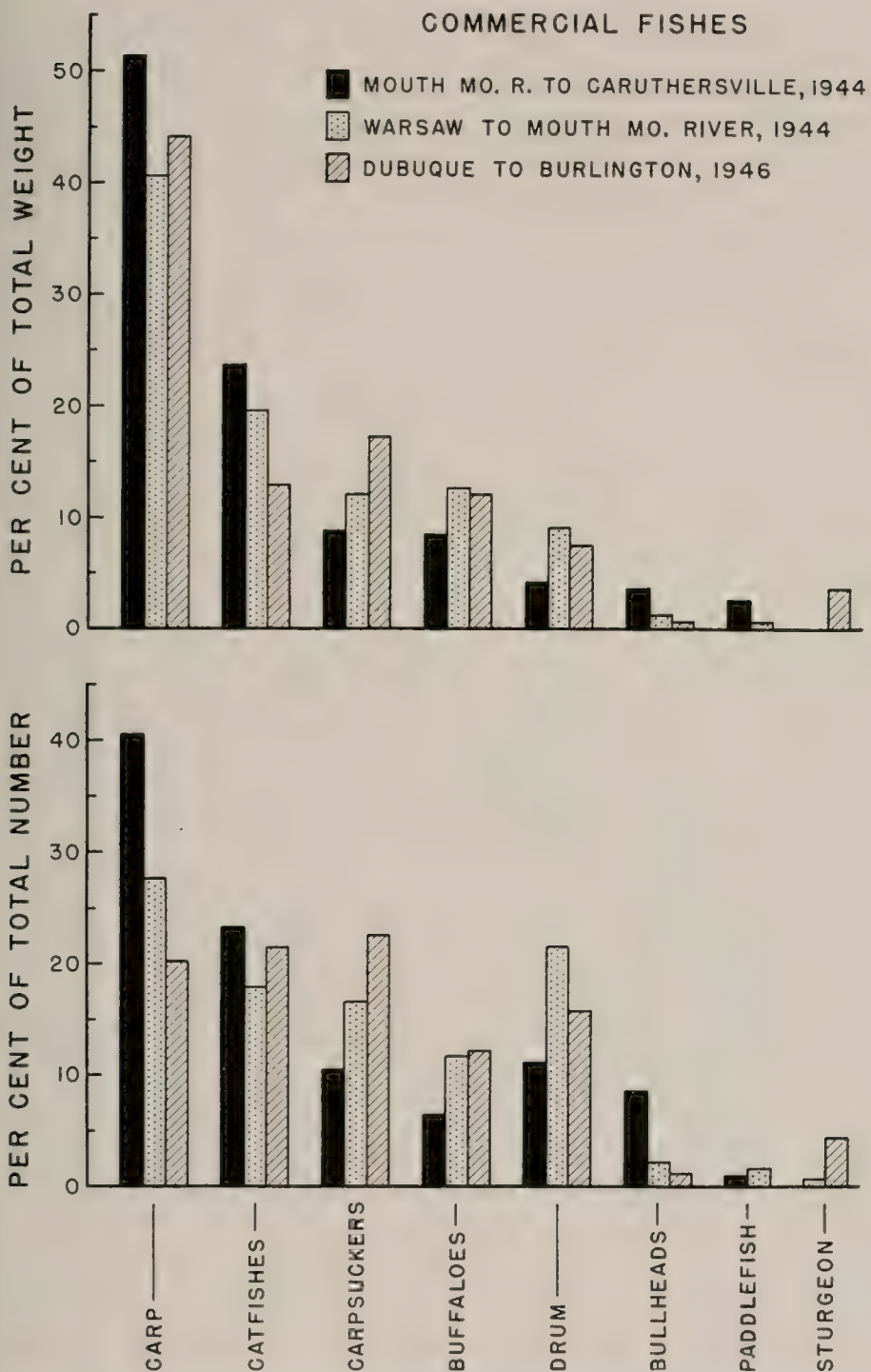


Fig. 7.—The relative abundance and the relative weight of each of various commercial fish groups taken in the test-net collections from three sections of the Mississippi River, 1944 and 1946.

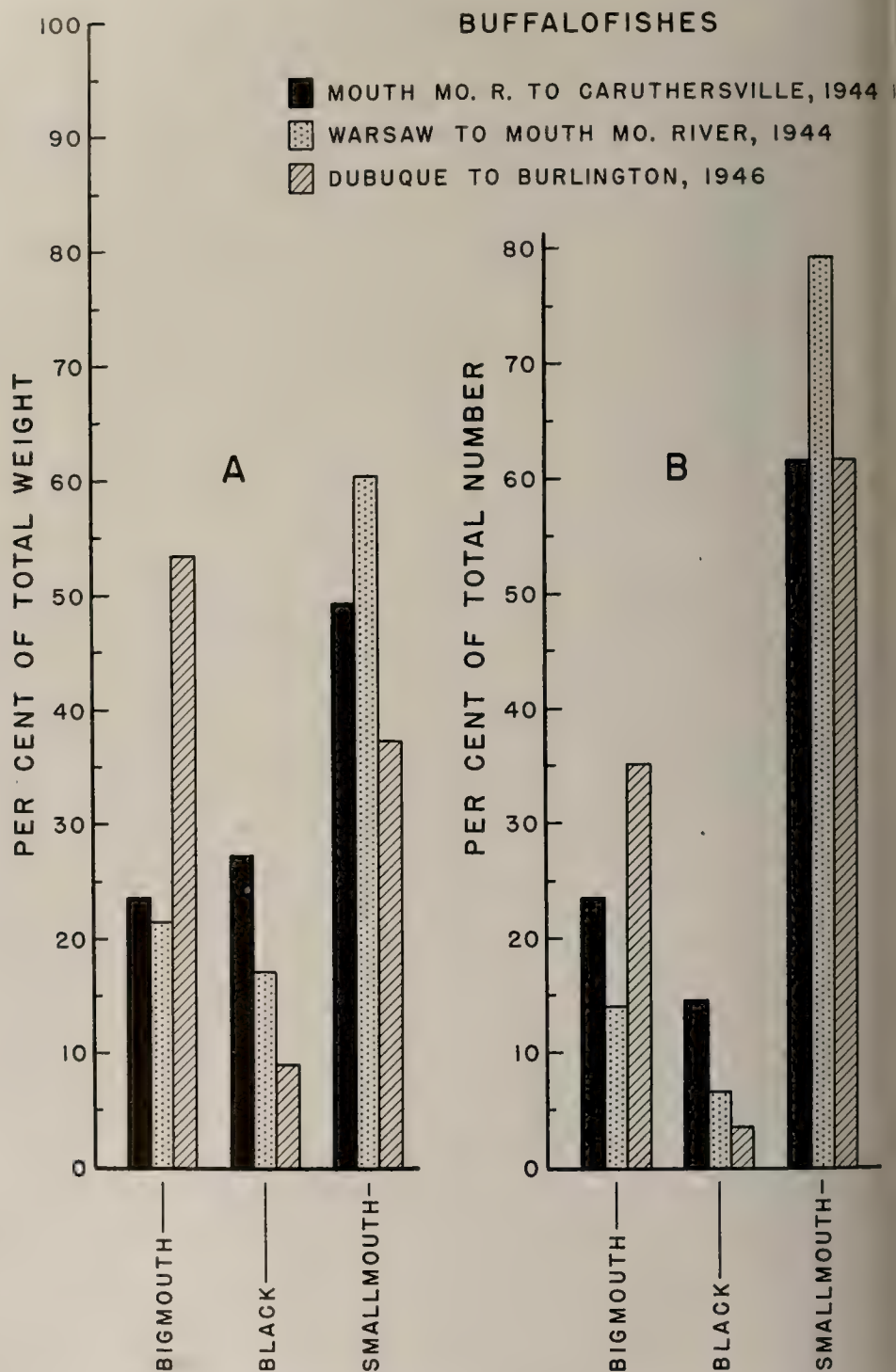


Fig. 8.—The relative weight and the relative abundance of each of three species of buffalofishes taken in the test-net collections from three sections of the Mississippi River, 1944 and 1946.

mouth collected was 2.57 pounds, much less than that of the black buffalo.

The smallmouth buffalo was by far the most abundant buffalofish taken in the survey; however, the average weight of 1.17 pounds for this species was considerably less than that for the other species. From a study of fig. 8, it becomes quite evident that on a weight basis the smallmouth buffalo was dominant in the survey catches in the MR-C section and that part of the D-MR section investigated in 1944, and that the bigmouth buffalo dominated the 1946 catches, which were in the Burlington-Dubuque section of the river. Numerically, the smallmouth buffalo dominated the collections in all three sections of the river referred to in fig. 8.

The average lengths of the black buffalo and the bigmouth buffalo in the test-net collections were greater than the average length of the smallmouth buffalo, table 11.

Examination of a large number of specimens indicated that the smallmouth buffalo and the bigmouth buffalo become sexually mature at about 15 inches in length. So few specimens of black buffalo were examined that maturity size for this species was not determined; the smallest ripe female noted was 18.5 inches long.

In the test-net collections only 24 per cent of the smallmouth buffaloes but 75 per cent of the other buffalofishes equaled or exceeded 15 inches in length. Commercial fishermen using nets of legal mesh

Table 11.—Length-frequency distribution of buffalofishes (most of them in test-net collections) from the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, in 1944 and 1946.

TOTAL LENGTH IN INCHES	SMALLMOUTH BUFFALO			BLACK BUFFALO*			BIGMOUTH BUFFALO		
	MR-C Section 1944	D-MR Section 1944	D-MR Section 1946	MR-C Section 1944	D-MR Section 1944	D-MR Section 1946	MR-C Section 1944	D-MR Section 1944	D-MR Section 1946
3.8-4.7....	—	—	24	—	—	—	—	—	1
4.8-5.7....	3	4	30	2	—	—	1	—	1
5.8-6.7....	7	5	21	—	—	—	—	1	3
6.8-7.7....	7	14	36	—	—	—	1	1	1
7.8-8.7....	5	29	56	3	—	1	1	—	2
8.8-9.7....	16	26	34	—	—	—	1	1	2
9.8-10.7....	16	44	22	1	1	—	1	2	4
10.8-11.7....	17	63	25	1	—	1	6	1	6
11.8-12.7....	4	48	28	1	2	—	14	1	5
12.8-13.7....	10	36	40	1	2	1	6	3	10
13.8-14.7....	7	15	50	3	3	1	2	12	12
14.8-15.7....	5	20	61	1	1	4	—	7	31
15.8-16.7....	4	13	36	1	4	2	2	16	63
16.8-17.7....	6	10	18	2	4	2	3	9	47
17.8-18.7....	9	6	15	—	3	1	—	4	50
18.8-19.7....	3	3	1	1	2	5	1	2	25
19.8-20.7....	2	2	3	3	—	1	3	—	25
20.8-21.7....	2	—	1	1	2	4	3	—	4
21.8-22.7....	1	1	—	—	1	1	2	—	1
22.8-23.7....	—	—	—	3	2	1	1	1	1
23.8-24.7....	—	2	—	5	—	5	—	—	—
24.8-25.7....	—	—	1	—	—	3	—	—	1
25.8-26.7....	—	—	2	—	—	1	—	—	—
26.8-27.7....	—	—	—	1	1	—	—	—	—
27.8-28.7....	1	—	1	—	—	1	—	—	—
28.8-29.7....	—	—	—	—	—	1	—	—	—
29.8-30.7....	1	—	—	—	—	1	—	—	—
30.8-31.7....	—	—	—	—	—	—	—	—	—
31.8-32.7....	1	—	—	—	—	—	—	—	—
Total number...	127	341	505	30	38	37	48	61	295
Average length.....	12.6	11.8	11.6	17.0	17.3	20.3	14.2	15.3	16.6

* The D-MR 1946 data include 19 specimens of smallmouth buffalo, 8 of black buffalo, and 18 of bigmouth buffalo caught with commercial gear by J. O. Kurre in the Burlington area.

sizes catch a higher percentage of small-mouth buffaloes of 15 inches or more in length than was taken in this investigation, in which some nets of smaller mesh sizes were used.

Carp

CYPRINIDAE

The carp is a native of neither Europe nor America. According to Hessel (1878: 865-6), in all probability it was introduced into Europe from Central Asia many centuries ago. Europeans have reared and cultivated it at least since 1227, and they consider it as an excellent food fish. During the nineteenth century many of our forefathers, then recent immigrants from Europe, clamored for the introduction of carp into North America. Various attempts evidently were made in carp plantings; in 1877 the United States Fish Commission was successful in importing a shipment of 345 carp, of which 227 were of the mirror and leather varieties. These carp were released in ponds at Washington, D. C., where they multiplied rapidly. In 1879, 12,000 young produced in the Washington ponds were distributed among more than 300 persons in 25 states and territories (Forbes & Richardson 1920:105):

Carp apparently were not planted directly by man into the Mississippi but escaped from nearby carp ponds during floods. Reports of carp in the Caruthersville-Dubuque section of the Mississippi came in 1883 from Hannibal, Missouri, and Quincy, Illinois (Cole 1905:549). Garman (1890:143) studied the fish fauna of the Mississippi bottoms near Quincy in August, 1888, and from his observations there wrote the following regarding the carp: "This hardy fish seems destined to become a permanent part of our fauna." In this 1888 investigation Garman found the carp widely distributed throughout the bottomland lakes.

The carp did not increase in the commercial catch of the Mississippi as rapidly as in its more productive tributary, the Illinois River. In 1899 nearly six times as many pounds of carp were taken from the Illinois River as were taken by Illinois commercial fishermen from the Mississippi (Townsend 1902:681).

The commercial statistics in tables 7 and 9 reveal the importance of the carp in the Mississippi River commercial fishery. The carp is now the most important commercial fish in the river and it would be only a matter of speculation as to what the size of the catch of the other fishes would be if carp were not in the present fauna.

The survey catch of carp in 1944 and 1946 was high at most of the stations, ranging from 12 to 70 per cent by weight of the catch of all the commercial fishes. Fig. 7, in which the catch of carp is presented as a per cent of the total weight of the commercial fishes caught in the test nets, demonstrates the significance of the carp to the commercial fishery. The carp was by far the most important commercial species, as such groups as catfishes, carp-suckers, and buffalofishes are composed of more than one species. The position of the carp in relation to all fishes taken at the several survey stations is shown graphically in fig. 9.

In fishery management the size and age of the fishes comprising the catch are basic to an analysis of the condition of a fishery. The average lengths and weights of carp taken by test netting at the various stations were recorded and are given in table 12. Carp have been reported from Europe as attaining weights of 42 to 67 pounds (Hessel 1878:874) and some of the scales from a 67-pound fish were said to measure 2.5 inches in diameter. Occasionally carp weighing 25 to 35 pounds are taken by commercial fishermen from the Mississippi; however, the average weight of the carp appearing in the survey catch was 2.65 pounds.

The difference between the average weights of the carp taken in 1944 and the average weights of those taken in 1946 appears by inspection of table 12 to be associated with the presence of relatively few small carp in the 1946 collections and relatively large numbers of small ones in 1944. A difference of this kind might be expected in any population after a lapse of 2 years and might be the result of differential survival of year classes.

The difficulties involved in attempting to determine by the scale method the age of summer-caught carp from a heterogeneous carp population composed of a

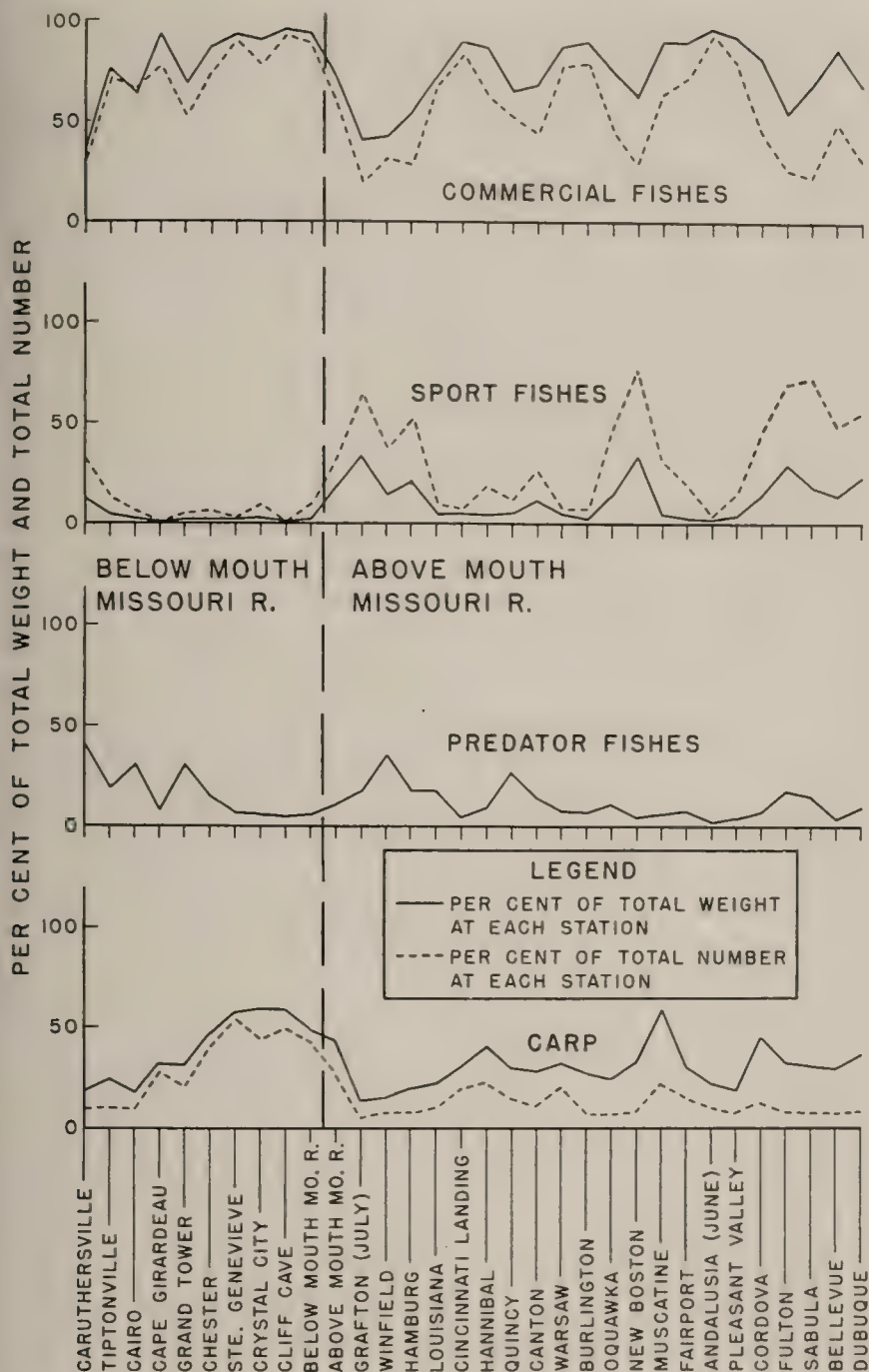


Fig. 9.—The relative weight and the relative abundance of each of several groups of fishes taken in test-net collections in the Caruthersville-Dubuque section of the Mississippi River. The curves are based on the per cents of total weight and of total number of all the fish collected at each station. Sampling was conducted at stations between Caruthersville and Warsaw in 1944 and between Burlington and Dubuque in 1946.

Table 12. Concluded.

Total Length in Inches	QUINCY, ILL. SEPT. 2-6	CANTON, MO. SEPT. 8-13	WARSAW, ILL. SEPT. 14-19	BURLINGTON, IA. APRIL 10-22, '46	OQUAWKA, ILL. APRIL 24-MAY 5	NEW BOSTON, ILL. MAY 7-18	MUSCATINE, IA. MAY 19-30	FAIRPORT, IA. JUNE 2-13	ANDALUSIA, ILL. APRIL 1-7	ANDALUSIA, ILL. JUNE 18-26	ANDALUSIA, ILL. SEPT. 15-24	PEASANT VALLEY, IA. JUNE 28-July 9	CORDOVA, ILL. JULY 11-22	PULTON, ILL. JULY 24-AUG. 4	SABULA, IA. AUG. 6-17	BELLEVEUE, IA. AUG. 19-30	DUBUQUE, IA. SEPT. 1-12	Total or Average
38-47	1			1														1
48-57				1														28
58-67				1														28
68-77				1														22
78-87				1														96
88-97				1														50
98-107				1														84
108-117				1														89
118-127				1														159
128-137				1														385
138-147				1														397
148-157				1														442
158-167				1														418
168-177				1														396
178-187				1														352
188-197				1														249
198-207				1														209
208-217				1														140
218-227				1														106
228-237				1														69
238-247				1														44
248-257				1														28
258-267				1														23
268-277				1														13
278-287				1														8
288-297				1														3
298-307				1														3
308-317				1														3
318-327				1														1
328-337				1														1
Total number	137	52	114	72	33	91	210	83	14	93	333	38	70	132	52	12	65	3,670
Average length	16.8	17.4	16.0	15.9	19.5	18.8	18.7	18.1	19.8	19.4	18.2	19.9	19.5	17.8	19.9	20.2	20.4	16.5
Average weight in pounds	2.52	2.68	2.23	3.37	3.85	3.56	3.71	3.17	3.61	3.62	3.35	4.13	4.37	3.54	4.19	4.70	4.96	2.65

Table 13.—Ranges and averages of Indices of Condition (C) of two length-groups of carp in test-net collections from the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, in 1944 and 1946.

STATION	CARP WITH TOTAL LENGTH OF 14.6 INCHES TO 15.5 INCHES			CARP WITH TOTAL LENGTH OF 16.6 INCHES TO 17.5 INCHES		
	Number	Range of C	Average C	Number	Range of C	Average C
<i>1944</i>						
Caruthersville.....	3	4.77-5.20	4.96	1	—	6.32
Tiptonville.....	16	4.32-6.80	5.43	3	4.83-6.30	5.37
Cairo.....	12	5.13-6.60	5.83	1	—	5.37
Cape Girardeau.....	9	4.65-5.64	5.22	9	4.68-6.37	5.59
Grand Tower.....	18	4.56-6.07	5.46	3	4.15-5.36	4.82
Chester.....	18	5.20-7.11	5.83	13	3.38-6.49	5.15
Ste. Genevieve.....	55	3.38-6.36	5.51	26	4.63-6.60	5.44
Crystal City.....	35	4.56-5.78	5.33	15	4.23-6.39	5.36
Cliff Cave.....	14	4.15-5.98	5.37	24	4.86-6.26	5.39
Mouth Missouri.....	26	4.81-5.82	5.16	8	4.55-5.63	4.93
Grafton (March).....	3	5.12-5.32	5.19	3	4.87-5.42	5.18
Grafton (July).....	6	4.60-5.06	4.85	2	4.26-5.04	4.65
Grafton (Sept.).....	5	4.54-5.11	4.79	1	—	5.10
Winfield.....	14	3.24-5.72	4.76	4	4.57-5.56	5.11
Hamburg.....	14	3.46-5.94	4.65	6	4.11-5.07	4.57
Louisiana.....	5	4.18-5.17	4.61	5	4.09-4.70	4.47
Cincinnati Landing.....	10	4.35-5.00	4.63	9	3.51-5.13	4.56
Hannibal.....	15	4.05-5.07	4.68	2	4.56-5.09	4.82
Quincy.....	12	2.87-5.56	4.65	23	4.21-5.52	4.93
Canton.....	6	4.56-5.10	4.81	5	4.44-5.20	4.80
Warsaw.....	0	—	—	14	4.29-5.92	5.08
<i>1946</i>						
Burlington.....	0	—	—	6	2.63-5.84	4.87
Oquawka.....	0	—	—	0	—	—
New Boston.....	2	4.68-4.89	4.79	8	4.03-6.11	4.99
Muscatine.....	18	4.74-6.55	5.59	22	4.43-6.38	5.06
Fairport.....	9	4.63-5.67	5.20	8	4.56-5.54	4.96
Andalusia (April).....	0	—	—	2	5.27-5.43	5.35
Andalusia (June).....	3	4.95-5.98	5.46	12	4.81-5.68	5.22
Andalusia (Sept.).....	7	5.03-5.78	5.30	66	4.27-6.23	5.09
Pleasant Valley.....	0	—	—	3	4.30-5.54	4.75
Cordova.....	2	3.83-4.88	4.36	6	4.50-5.93	4.94
Fulton.....	7	4.72-5.27	4.99	11	4.51-5.52	4.97
Sabula.....	3	4.35-4.87	4.57	11	4.22-5.32	4.73
Bellevue.....	2	4.94-5.53	5.24	2	4.57-6.09	5.33
Dubuque.....	1	—	4.93	2	4.32-5.18	4.75

number of year classes overlapping in length ranges have been discussed by Frey (1942:217). Because of these difficulties, it was necessary to rely on the length-frequency method of aging even though it, too, has limitations and is not well suited for use on carp populations. From the data given in table 12, it appears that the bulk of the carp catch was composed of 2- and 3-year-old fish.

It was determined by examining the gonad condition of carp taken in the survey that sexual maturity was reached in the females at lengths of 14 to 15 inches, in most males at lengths of 12.5 to 14.5 inches. However, some males as small as

8.5 inches were mature. The catches made by test-netting indicate that many carp below these lengths are taken in commercial type gear. The over-all average length of carp taken in both years of the survey was 16.5 inches, a figure a little over the minimum maturity length.

The Index of Condition (C)* is often used as an indicator of the relative plumpness of a fish. In table 13 the ranges and averages of Indices of Condition are given for two length groups of carp. At many

* The formula $C = \frac{W}{L^3} \times 10,000$ suggested by Thompson & Bennett (1939:17) was used in computing the Index of Condition.

stations too few specimens of the selected length groups were taken to permit direct comparison; however, where 10 or more specimens were taken it seemed justifiable to make comparisons. The Index of Condition, or C, ranged from 2.63 to 7.11. Carp having a C below 3.50 gave an outward appearance of being in poor condition and most of them were emaciated. Inspection of table 13 indicates that the average C is a little less than 5.00. Most of the carp taken in the spring and early summer (in the MR-C section) had a C above this value; most of those taken later in the season of the same year (in the D-MR section) had a C below 5.00. A similar seasonal difference was noted also at the two key stations. The upper C range at the key stations, as well as at the majority of the other stations, was above 5.00. The average C of carp taken in the polluted waters below St. Louis was much higher than that for carp taken above St. Louis. This difference may be attributed partly or entirely to seasonal changes.

In the section of this paper on "Pollution" mention is made that the carp on the Illinois side of the Mississippi near Warsaw appeared very fat; their condition was attributed to their feeding upon brewery waste. It is of interest to note in table 13 that the average Index of Condition was higher at Warsaw than at the preceding stations below it sampled in late summer.

Catfishes and Bullheads

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The catfishes are considered by many to be the finest-tasting fresh-water fishes in North America. Their white, firm flesh has long made them leaders in demand at midwestern river commercial fish markets. Commercial fishermen frequently are unable to meet the local public demand for these food fishes. The catfishes are popular with anglers, also. It is often said that an angler who has never tried fishing with a light rod for the channel catfish (*Ictalurus lacustris*) has "just never



Fig. 10.—A Mississippi River commercial fisherman dressing a catfish. An experienced fisherman can dress a catfish in less than a minute.



Fig. 11.—Raising a small-mesh hoop net on the Mississippi River. The small-mesh nets are particularly effective for catfish.

fished." The flathead catfish (*Pilodictis olivaris*) and the blue catfish (*Ictalurus furcatus*) are regularly taken by anglers either by trotline fishing or by jug fishing.

In the Mississippi the three species of catfishes mentioned above form an important part of the commercial catch, figs. 10, 11, and 12. The species of catfishes and

bullheads, like the species of buffalofishes, are usually lumped together in commercial fisheries statistics. The commercial catch of Mississippi River catfishes and bullheads reported for Illinois and Iowa in 1946 amounted to a little more than 50 per cent of the comparable catch reported in 1899, table 7. This table shows the



Fig. 12.—Removing catfish from a basket trap. In the spring commercial fishermen often "bait" this type of trap with a ripe female catfish.

large decline that occurred in the commercial take of these fishes between 1894 and 1899. The Illinois catch of catfishes and bullheads from the Mississippi, table 9, amounted to 20.3 per cent of the weight of the total commercial catch in 1894 and 15.1 per cent of that catch in 1946. These figures are hardly comparable in view of the change in abundance of other commercial fishes. At Lake Keokuk the largest commercial catch of catfishes and bullheads since 1914 was taken in 1936, table 8. This table indicates that in 1936 a large increase in catch occurred on the Illinois side of the Mississippi from Lake Keokuk to the northern boundary of the state. The following year the catch in that part of the river was reduced by almost one-half.

The test-net data obtained between Caruthersville and Dubuque reveal that the relative abundance of the catfish species is not constant in the three sections of the Mississippi indicated in fig. 13. By weight, the flathead was the most important catfish in all three sections, fig. 13. Numerically, the flathead was the most important catfish in the MR-C section and the channel catfish the most important in the other two sections. The blue cat-

fish was more abundant in the MR-C section than in the D-MR section. No specimen of this species was taken in test nets above Warsaw. About 20 years ago Coker (1930:175) noted that Keokuk, which is 4 miles above Warsaw, was about the northern limit of the summer range of the blue catfish.

The channel catfish was reported by Forbes & Richardson (1920:181) as occasionally attaining a weight of 15 to 20 pounds. The largest specimen of this species observed during the 2 years of this investigation was taken at Burlington; it weighed 13.06 pounds. The average weight of the channel catfish in the test-net catches was 0.45 pound, Appendix B.

The flathead catfish was reported by Forbes & Richardson (1920:194) as frequently reaching a weight of 50 to 75 pounds and by Evermann (1899:293) as attaining a weight of 50 to 60 pounds and, rarely, 100 pounds. At Cincinnati Landing a flathead catfish weighing 42.56 pounds was taken by the 1944 survey party in a wing net. The average weight of the flathead in the test-net collections was 3.08 pounds, Appendix B.

The average weight of the blue catfish in the test-net collections was surprisingly

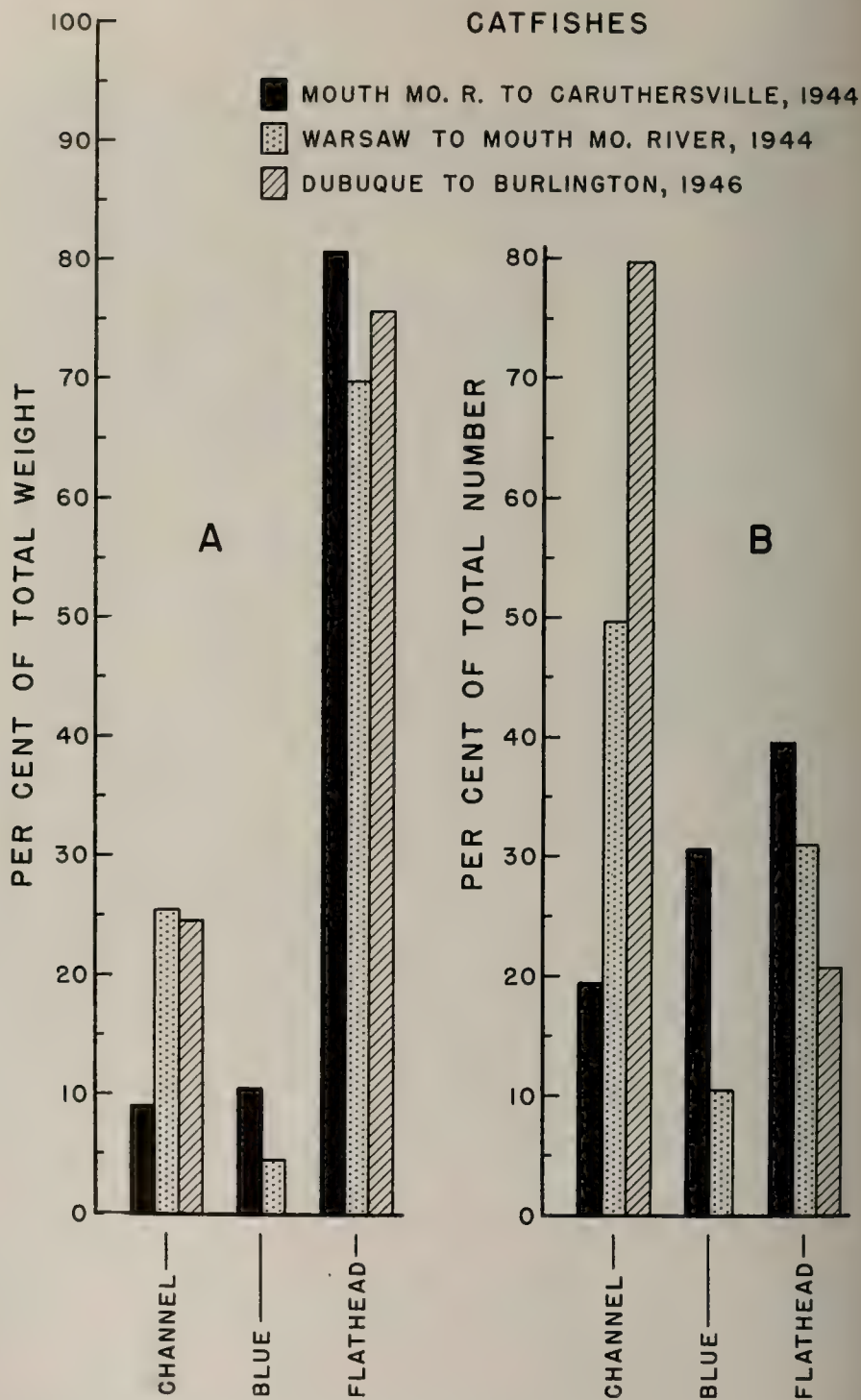


Fig. 13.—The relative weight and the relative abundance of each of three species of catfishes taken in test-net collections from three sections of the Mississippi River, 1944 and 1946.

low, only 0.57 pound, Appendix B, table 1. This species is principally southern in distribution and evidently forms a substantial part of the catch in the lower part of the Mississippi, particularly in Louisiana. Evermann (1899:292) stated more

5 years old. The size at which they attain maturity was found to vary considerably. A few mature female flathead catfish less than 15 inches total length were noted; however, the majority of mature females were 18 inches or more in length. The

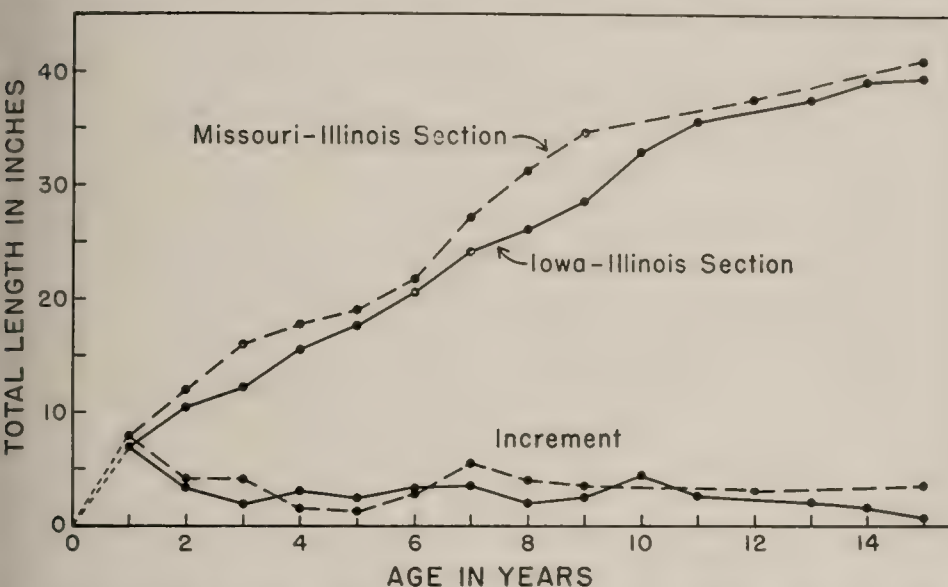


Fig. 14.—Average growth rates of flathead catfish taken in the Missouri-Illinois and Iowa-Illinois sections of the Mississippi River as determined from test-net collections, 1944 and 1946.

than 50 years ago that at Morgan City and Melville, Louisiana, the blue catfish and the flathead catfish constituted probably 98 per cent of the entire catch. Later Gowanloch (1933:421) mentioned that blue catfish weighing 150 pounds were caught occasionally and quoted Evermann as having been informed of one specimen weighing 185 pounds and another 250 pounds. Reports by commercial fishermen of 75- and 90-pound blue catfish were not uncommon in the section of the river near Caruthersville. No catfish of these large sizes were taken in the test nets.

Age determinations of the channel catfish and flathead catfish were made from specimens collected during the survey; they were based on the number of rings or annuli on the vertebrae. The number of annuli on the vertebrae of the blue catfish could not be discerned with any degree of accuracy. From the growth studies it appears that channel catfish and flathead catfish do not mature until they are 4 or

channel catfish was found to mature at lengths between 12 and 15 inches. Too few blue catfish were examined to determine maturity size for this species.

Growth of the channel catfish and flathead catfish was faster in the Missouri-Illinois section of the river than in the Iowa-Illinois section, fig. 14.

The length-frequency distribution of the catfishes from the test-netting collections is given in table 14. A line of demarcation is drawn on table 14 to set off the approximate size at which maturity is attained among the catfishes. The 15-inch set-off for the blue catfish is purely arbitrary.

Three species of bullheads were taken from the river during the 2 years of test-netting. As shown in table 15, the black bullhead (*Ameiurus melas*) made up 5.6 per cent of the total number of all fishes taken in the MR-C section in 1944. In that part of the D-MR section sampled that same year the black bullhead dropped

to an insignificant 0.6 per cent and in that part sampled in 1946 to 0.5 per cent. Black bullheads were taken in numbers at only four of the stations in the MR-C section, Appendix B, table 1. The black bullheads taken at these stations represented 82 per cent of the number of this species

caught in 1944 and 68 per cent of all the black bullheads taken in the entire survey. At the six stations immediately below the canalized section of the river (stations south of Grafton) only five black bullheads were caught, numerically 1.6 per cent of the 1944 catch of black bullheads.

Table 14.—Length-frequency distribution of the catfishes in test-net collections from the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, in 1944 and 1946. The horizontal broken rule marks the approximate dividing line between immature and mature fish; the line for the blue catfish is based on little evidence and is therefore questionable.

TOTAL LENGTH IN INCHES	CHANNEL CATFISH			FLATHEAD CATFISH			BLUE CATFISH	
	MR-C Section 1944	D-MR Section 1944	D-MR Section 1946*	MR-C Section 1944	D-MR Section 1944	D-MR Section 1946*	MR-C Section 1944	D-MR Section 1944
2.8-3.7.....	—	1	6	—	—	—	—	—
3.8-4.7.....	—	—	3	—	—	1	—	1
4.8-5.7.....	—	1	2	—	—	2	—	—
5.8-6.7.....	—	4	99	—	—	2	7	—
6.8-7.7.....	4	14	221	—	3	12	15	4
7.8-8.7.....	24	14	228	5	6	3	22	17
8.8-9.7.....	34	20	210	5	2	11	30	19
9.8-10.7.....	15	29	111	7	7	11	40	5
10.8-11.7.....	11	42	69	9	8	17	41	6
11.8-12.7.....	5	60	34	13	13	20	23	4
12.8-13.7.....	4	32	27	18	19	20	13	4
13.8-14.7.....	8	23	32	22	15	17	9	10
14.8-15.7.....	11	26	33	35	29	22	13	5
15.8-16.7.....	4	15	18	42	28	22	4	—
16.8-17.7.....	11	14	10	46	28	26	6	2
17.8-18.7.....	3	7	12	42	24	18	1	2
18.8-19.7.....	6	8	2	34	17	5	3	—
19.8-20.7.....	1	4	7	17	12	11	2	—
20.8-21.7.....	1	2	1	17	5	12	—	—
21.8-22.7.....	2	1	2	12	6	3	—	1
22.8-23.7.....	1	1	2	11	2	7	1	—
23.8-24.7.....	3	—	3	8	1	3	—	—
24.8-25.7.....	—	—	1	7	4	11	—	—
25.8-26.7.....	—	1	—	5	7	7	—	—
26.8-27.7.....	—	—	—	5	1	4	—	—
27.8-28.7.....	—	—	1	2	1	5	—	—
28.8-29.7.....	—	—	—	2	1	1	—	—
29.8-30.7.....	—	1	1	3	—	1	—	—
30.8-31.7.....	—	—	1	1	1	1	—	—
31.8-32.7.....	—	—	—	—	1	5	1	—
32.8-33.7.....	—	—	—	—	1	2	—	—
33.8-34.7.....	—	—	—	—	—	1	—	—
34.8-35.7.....	—	—	—	1	1	2	—	—
35.8-36.7.....	—	—	—	2	—	2	—	—
36.8-37.7.....	—	—	—	1	1	5	—	—
37.8-38.7.....	—	—	—	—	—	1	—	—
38.8-39.7.....	—	—	—	—	—	2	—	—
39.8-40.7.....	—	—	—	—	—	—	—	—
40.8-41.7.....	—	—	—	—	1	—	—	—
Total number.....	148	320	1,136	372	245	295	231	80
Average length.....	12.3	12.8	9.6	17.9	17.0	17.5	11.3	11.0
Per cent mature length.....	29.1	25.0	8.3	45.7	35.5	36.9	13.4	12.5

* The 1946 D-MR data include 24 channel catfish and 2 flathead catfish caught near Burlington, Iowa, by J. O. Kurrel, a commercial fisherman.

Table 15.—Species composition of Mississippi River fishes taken above and below the mouth of the Missouri River between Caruthersville, Missouri, and Dubuque, Iowa, 1944 and 1946.

SPECIES	MOUTH OF MISSOURI RIVER TO CARUTHERSVILLE, 1944			WARSAW TO MOUTH OF MISSOURI RIVER, 1944			DUBUQUE TO BURLINGTON (ABOVE MOUTH OF MISSOURI RIVER), 1946		
	Per Cent of Total Stations (10) at Which Listed Species Were Taken	Number of Specimen	Per Cent of Total Number of All Fish	Per Cent of Total Stations (12) at Which Listed Species Were Taken	Number of Specimen	Per Cent of Total Number of All Fish	Per Cent of Total Stations (14) at Which Listed Species Were Taken	Number of Specimen	Per Cent of Total Number of All Fish
COMMERCIAL FISHES									
<i>Aplocheilichthys albus</i>	—	0	—	8	1	0.01	—	0	—
Hornednose sturgeon.....	—	0	—	8	3	0.03	29	281	2.24
Spottail shiner.....	40	24	0.51	42	52	0.59	—	0	—
Spottail shiner.....	30	10	0.21	25	25	0.31	79	1	0.14
American eel.....	—	0	—	17	3	0.03	21	5	0.04
Blue sucker.....	—	0	—	92	61	0.69	100	277	2.21
Bigmouth buffalo.....	70	48	1.02	83	28	0.32	86	29	0.23
Black buffalo.....	60	30	0.64	100	341	3.88	93	486	3.88
Smallmouth buffalo.....	80	127	2.69	100	605	6.88	100	1,491	11.90
<i>Carpioides</i> spp.....	100	334	7.08	—	0	—	21	6	0.05
White sucker.....	—	0	—	—	0	—	14	2	0.02
Spotted sucker.....	—	0	—	—	0	—	7	1	0.01
Silver redhorse.....	—	0	—	—	0	—	—	—	—
Northern redhorse.....	10	7	0.15	58	13*	0.15	93	104	0.83
Carp.....	100	1,311	27.80	100	1,014	11.53	100	1,347	10.76
Channel catfish.....	100	148	3.14	100	320	3.64	100	1,115	8.90
Blue catfish.....	100	231	4.90	100	80	0.91	—	0	—
Yellow bullhead.....	20	4	0.08	50	24	0.27	29	10	0.08
Brown bullhead.....	10	1	0.02	17	5	0.06	—	0	—
Black bullhead.....	70	262	5.56	50	48	0.55	79	65	0.52
Flathead catfish.....	100	372	7.89	92	245	2.78	100	294	2.35
Freshwater drum.....	100	348	7.38	100	768	8.73	100	1,088	8.69
Subtotal.....	—	3,257	69.08	—	3,638	41.35	—	6,618	52.85
SPORT FISHES									
Pike.....	—	0	—	—	0	—	36	35	0.28
Grass pickerel.....	—	0	—	8	2	0.02	—	0	—
Yellow pikeperch.....	—	0	—	17	2	0.02	57	17	0.14
Sauger.....	60	21	0.45	75	46	0.52	71	68	0.54
Spotted black bass.....	10	2	0.04	—	0	—	7	2	0.02
Largemouth black bass.....	50	10	0.21	58	123	1.40	64	18	0.14
Green sunfish.....	20	18	0.38	—	0	—	21	3	0.02
Bluegill.....	70	39	0.83	67	556	6.32	86	308	2.46
Warmouth.....	30	15	0.32	25	52	0.59	36	10	0.08
Flier.....	10	1	0.02	—	0	—	—	0	—
White crappie.....	70	119	2.52	100	879	9.99	100	2,677	21.38
Black crappie.....	70	123	2.61	100	1,392	15.82	100	1,452	11.60
White bass.....	50	24	0.51	83	193	2.19	93	162	1.29
Yellow bass.....	20	2	0.04	33	4	0.05	57	258	2.06
Subtotal.....	—	374	7.93	—	3,249	36.93	—	5,010	40.00
PREDATORY FISHES									
Longnose gar.....	90	51	1.08	100	143	1.63	93	38	0.30
Shortnose gar.....	100	602	12.77	100	809	9.20	100	209	1.67
Alligator gar.....	40	84	1.78	8	1	0.01	—	0	—
Bowfin.....	50	29	0.62	67	81	0.92	93	154	1.23
Subtotal.....	—	766	16.25	—	1,034	11.75	—	401	3.20
FORAGE FISHES									
Mooneye.....	70	43	0.91	92	66	0.75	79	174	1.39
Goldeye.....	—	—	—	—	—	—	64	84	0.67
Skipjack.....	30	11	0.23	17	4	0.05	—	0	—
Gizzard shad.....	70	264	5.60	100	805	9.15	86	237	1.89
Golden shiner.....	—	0	—	8	2	0.02	—	0	—
Subtotal.....	—	318	6.74	—	877	9.97	—	495	3.95
Total.....	—	4,715	100.00	—	8,798	100.00	—	12,521	100.00

* Includes one specimen of an undetermined species of redhorse (*Moxostoma*).

† The goldeye is included with the mooneye in the 1944 collections.

In July, 1944, at the Grafton station, 14 specimens of black bullheads were taken, Appendix B, table 1. As mentioned in Appendix A, some of the sampling done at this station was in the lower part of the Illinois River and adjoining bottomland lakes, and the catch there may not have been typical of the fish population in the Mississippi. At the next station above Grafton on the Mississippi, five black bullheads were taken, and at the next four stations none was caught. In the aggregate only four specimens were taken at the remaining three uppermost stations used in 1944. The number of black bullheads was low throughout that part of the D-MR section investigated in 1946. The largest number caught at one station in 1946 was 16, at Andalusia in June. The data for the various stations are contained in Appendix B.

The yellow bullhead (*Ameiurus natalis*) was taken at less than half of the stations and was plentiful at none, Appendix B. More specimens were taken at the upper than at the lower stations; however, considerably more than half of the yellow bullheads taken in the survey were caught at the Grafton station, and, as suggested above, the sampling there was not confined to the Mississippi.

Only six brown bullheads (*Ameiurus nebulosus*) were taken in 1944 and none in 1946, Appendix B. Of these only one was taken in the lower river and the remainder were caught at the Grafton station.

The scarcity of bullheads in the D-MR section of the river is reflected by the Iowa commercial catch between 1944 and 1948, table 16. For a few years following canalization of the upper Mississippi the commercial catch of bullheads increased, and it did not show a severe decline until 1944-45. The reason for the decline is not known. The test-net catch of bullheads in 1944 was low at the six sampling stations below the canalized section of the river. According to E. B. Speaker of the Iowa Conservation Commission (letter, August 19, 1949) there again is apparently some increase in the bullhead population in the Iowa section of the Mississippi.

Since so few bullheads were taken in 1946, the length-frequency data of only

Table 16.—Commercial catch of bullheads from the Iowa section of the Mississippi River, 1938-1948.*

YEAR	POUNDS CAUGHT
1938-39	74,246
1939-40	98,577
1940-41	189,129
1941-42	215,675
1942-43	203,040
1943-44	138,385
1944-45	52,158
1945-46	7,679
1946-47	15,618
1947-48	20,306

* Data furnished by E. B. Speaker, Superintendent of Biology Section, Iowa Conservation Commission.

Table 17.—Length-frequency distribution of bullheads in test-net collections from the Mississippi River between Caruthersville, Missouri, and Warsaw, Illinois, in 1944. The horizontal broken rule marks the approximate dividing line between immature and mature fish.

TOTAL LENGTH IN INCHES	BLACK BULL-HEAD	YELLOW BULL-HEAD	BROWN BULL-HEAD
5.8- 6.7	4	—	—
6.8- 7.7	9	1	—
7.8- 8.7	28	2	1
8.8- 9.7	52	2	—
9.8-10.7	98	13	2
10.8-11.7	68	6	—
11.8-12.7	35	3	1
12.8-13.7	11	1	1
13.8-14.7	3	—	1
14.8-15.7	1	—	—
15.8-16.7	1	—	—
Total number	310	28	6
Average length	10.4	10.5	11.4

the 1944 catch are included in table 17. In Illinois the present minimum legal length for bullheads is 9 inches. Age determinations made from vertebrae of the Mississippi River bullheads taken in 1944 tend to indicate that the majority of the black bullheads did not reach the maturity length of approximately 10 inches before the age of 3 years. The yellow bullheads, however, seem to have a more rapid growth rate and attained this length within 2 years. In the 1944 test-net samples, 70 per cent of the black bullheads were 10 inches or more in length. Of the 28 specimens of yellow bullheads taken, 82

per cent equaled or exceeded 10 inches in length.

The catfish and bullhead fishery between Caruthersville and Dubuque as demonstrated by the 2 years of test netting is largely a channel cat-flathead fishery. The only other important species of this group, the black bullhead and the blue catfish, are more numerous in the MR-C section than above. The great abundance of the channel catfish in the upper river perhaps compensates somewhat for the small numbers of bullheads in that section and the scarcity of the blue catfish in the river above Warsaw. Yellow bullheads and brown bullheads are too scarce in the river to be of any commercial importance.

Freshwater Drum

SCIAENIDAE

In the Midwest commercial market the freshwater drum is usually called white perch. In the Mississippi River this fish is of great importance commercially and of some value as a sport fish. According to Forbes & Richardson (1920:324), weights of 50 to 60 pounds were in their time not uncommon for this fish. In the opinion of these writers the freshwater drum "becomes tough and strong with age, but is at its best when weighing from three-quarters of a pound to three pounds. . . . This fish is of a sluggish habit, living on the bottom of muddy waters, where it feeds especially on mollusks, the shells first being crushed by the powerful, paved, millstone-like, pharyngeal jaws. Often the stomach contains only the soft bodies and opercula of gastropod mollusks, the crushed shells evidently having been thrown out. Crawfishes are also sometimes found in the food. Half-grown specimens feed largely on aquatic insects, especially the larvae of May-flies, mingling larger and larger proportions of mollusks with this food as they increase in size, until they come finally to depend almost wholly upon water-snails and the relatively thin-shelled clams."

Although the increased silt load and canalization have modified the Mississippi as an invertebrate habitat, the freshwater drum has evidently been able to withstand the changes and is still one of the most abundant fishes in the river. In the test-

netting study the freshwater drum was found to be abundant at all the sampling stations between Caruthersville and Dubuque.

In 1946 the freshwater drum ranked fourth in weight of catch among Mississippi River fish groups reported by commercial fishermen of Illinois, Iowa, and Missouri, table 7. It ranked second among species in the test-net survey, as the buf-falofish, carpsucker, catfish, and bullhead groups were each composed of more than one species. Its relative abundance in the three sections of the river indicated in table 15 did not vary appreciably.

The average weight of the freshwater drum in the survey catches was 0.67 pound, Appendix B. As shown in table 18 the average length for individuals of this species varied somewhat in the three sections indicated. Many more large individuals, that is, fish 14 inches or more in length, were taken in 1946 than in 1944.

Table 18.—Length-frequency distribution of the freshwater drum in test-net collections from the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, in 1944 and 1946. The horizontal broken rule marks the approximate dividing line between immature and mature fish.

TOTAL LENGTH IN INCHES	MR-C SECTION 1944	D-MR SECTION 1944	D-MR SECTION 1946*
3.8-4.7	—	12	25
4.8-5.7	4	36	121
5.8-6.7	28	44	59
6.8-7.7	34	117	80
7.8-8.7	24	99	122
8.8-9.7	36	82	129
9.8-10.7	43	80	70
10.8-11.7	39	69	70
11.8-12.7	58	99	77
12.8-13.7	51	81	92
13.8-14.7	11	40	125
14.8-15.7	10	10	86
15.8-16.7	—	4	54
16.8-17.7	—	4	20
17.8-18.7	1	—	7
18.8-19.7	—	—	7
21.8-22.7	—	—	1
Total number	339	777	1,145
Average length	10.5	9.9	10.6
Per cent mature fish	6.5	7.5	26.2

* The 1946 D-MR data include 58 specimens caught near Burlington, Iowa, by J. O. Kurre, a commercial fisherman.

Studies made on the scales of the freshwater drum from the Mississippi indicate that, on the average, the drum does not attain a length of 14 inches until it is 5 years of age in the Illinois-Missouri section and 6 years of age in the Illinois-Iowa section. The minimum legal length limit of 10 inches, which has been in effect for some time in the state of Illinois, appears to have allowed a favorable take without seriously depleting the population.

The length at which the freshwater drum matures was found to be variable. A female 10.5 inches in length was found spent, and individuals of 15.0 and 15.5 inches were determined as immature or developing. Probably length variation within a group is associated with the age of that group, since a wide length range for each age group was common.

In 1946 the freshwater drum commanded a price along the Mississippi about equal to that of the buffalofishes, approximately 10 cents a pound, undressed weight. In that year, undressed carp brought about 5 cents a pound and undressed catfish approximately 20 cents a pound.

SPORT FISHES

The sport fishery of the Mississippi River between Caruthersville and Dubuque is confined largely to the D-MR section. There sport fishing is, for the most part, conducted in the pools immediately below the dams and in backwaters and bottomland lakes adjoining the river.

Bluegills (*Lepomis macrochirus*) and crappies were by far the most abundant species of sport fishes in the test-net collections. Black basses, pike, sauger, and yellow pikeperch (walleye) were taken in only limited numbers. Experience has demonstrated that the black basses are not so susceptible to being caught in nets and seines as are most of the other fishes. This possibly explains the scarcity of black basses in many of the collections.

Fig. 9 portrays the abundance of sport fishes in the collections from test-net stations in the Caruthersville-Dubuque section of the river. In this figure it may be clearly seen that the sport fishes made up a smaller part of the total catch in the MR-C section of the river than in the

Table 19.—Relative abundance of individuals of the several groupings of Mississippi River fishes associated with upper, middle, and lower reaches of navigation pools between Burlington and Dubuque, Iowa, in 1946, expressed as per cents of total numbers and total weights of fishes.

LOCATION IN POOL AND STATION	COMMERCIAL		SPORT		PREDATOR		FORAGE		TOTAL	
	Per Cent of Total Num- ber	Per Cent of Total Weight	Per Cent of Total Num- ber	Per Cent of Total Weight	Per Cent of Total Num- ber	Per Cent of Total Weight	Per Cent of Total Num- ber	Per Cent of Total Weight	Num- ber of Fish	Pounds
<i>Upper Part</i>										
(New Boston, Ill., Pleasant Valley, Ia., Fulton, Ill., Dubuque, Ia.)	35.91	67.25	57.56	23.03	3.14	8.55	3.39	1.17	4,715	4,256.36
<i>Middle Part</i>										
(Burlington, Ia., Oquawka, Ill., Muscatine, Ia., Andalusia, Ill., Cordova, Ill., and Sabula, Ia.)	67.57	89.19	28.45	5.48	2.95	5.08	1.02	0.25	6,537	7,935.97
<i>Lower Part</i>										
(Fairport, Ia., and Bellevue, Ia.)	60.22	88.96	34.28	5.69	4.72	5.32	0.79	0.03	1,272	1,625.16

D-MR section. Because of the scarcity of adjoining backwaters and bottomland lakes, together with a high degree of turbidity in the channel, the MR-C section is visibly less satisfactory as a habitat for most of the sport fishes than the D-MR section. A much more favorable habitat for these fishes is provided by the D-MR section; however, the increased silt load of the river, silting above the dams, and the draining of adjoining bottomland lakes have contributed toward reducing the potentialities of this section of the river for sport fishes.

Netting operations in the various parts of the pools formed by the dams in the D-MR section revealed that the game fishes were most abundant in the upper reaches. The catches of all fishes in the upper, middle, and lower reaches of the pools are summarized in tables 19 and 20. A relative increase in the catch of commercial fishes occurred in the middle and lower reaches as the intensity of fishing was increased there, although the total

catch (all species combined) per net-day actually dropped. The relative increase in the catch of commercial fishes as reflected by table 19 is due partly to the scarcity of sport fishes in catches from the middle and lower reaches. The upper reaches of the pools provide a more favorable habitat for sport fishes than the middle and lower reaches in that the bottoms in the upper reaches are comparatively free of silt. Here probably more food is available in the form of aquatic insects and minnows than over the silt-covered bottoms in the middle and lower reaches of the pools. Deep holes and shallow sand bars are rather numerous in the upper reaches of the pools, and this type of habitat is usually considered favorable for sport fishes.

Early in this century, and before, sport fishes were taken commercially from the Mississippi. During the year 1899, Townsend (1902:681) reports, 18,744 pounds of "black bass" were caught commercially by Illinois fishermen from the Mississippi and 102,579 pounds from the Illinois

Table 20.—The 1946 hoop-net and wing-net catches expressed in average numbers and weight of fish per net-day in relation to location in navigation pools of the Mississippi River between Burlington and Dubuque, Iowa.

LOCATION IN POOL AND STATION	1-INCH MESH WING NET		2½-INCH MESH WING NET		1-INCH MESH HOOP NET		2½-INCH MESH HOOP NET	
	Average Number of Fish per Net-	Average Weight of Fish per Net-	Average Number of Fish per Net-	Average Weight of Fish per Net-	Average Number of Fish per Net-	Average Weight of Fish per Net-	Average Number of Fish per Net-	Average Weight of Fish per Net-
	Day	Day	Day	Day	Day	Day	Day	Day
<i>Upper</i>								
New Boston.....	17.66	10.09	1.68	5.07	4.12	1.13	0.98	3.01
Pleasant Valley.....	7.71	7.15	1.24	4.22	1.14	0.84	1.04	4.38
Fulton.....	24.91	12.59	1.33	3.55	6.05	7.73	2.30	6.60
Dubuque.....	10.16	5.97	0.91	3.68	2.22	0.70	0.59	2.42
Average for upper part...	15.11	8.95	1.29	4.13	3.38	2.60	1.23	4.10
<i>Middle</i>								
Burlington.....	13.92	6.32	1.50	5.29	4.21	2.10	1.13	2.64
Oquawka.....	7.58	5.05	1.58	4.58	0.73	1.89	1.32	2.92
Muscatine.....	6.56	3.09	0.81	2.05	0.75	0.28	2.16	4.75
Sabula.....	11.01	5.04	0.51	1.39	1.76	2.39	0.47	2.91
Andalusia (April).....	6.99	4.43	1.44	4.50	1.18	0.40	0.15	0.30
Andalusia (June).....	9.02	9.16	2.76	7.37	5.33	6.87	4.45	8.53
Andalusia (Sept.).....	6.32	3.14	0.88	2.65	1.70	2.72	0.51	1.55
Cordova.....	7.48	5.40	0.79	2.45	4.49	2.16	0.57	3.12
Average for middle part...	8.61	5.20	1.28	3.79	2.52	2.35	1.35	3.34
<i>Lower</i>								
Fairport.....	5.51	5.54	1.71	3.89	0.11	0.02	0.55	2.52
Bellevue.....	6.76	3.77	0.43	1.47	0.80	1.18	0.47	2.49
Average for lower part...	6.13	4.66	1.07	2.68	0.46	0.60	0.51	2.51

River; 33,641 pounds of "sunfish" were taken from the Mississippi and 507,680 pounds from the Illinois. These statistics indicate that the section of the Mississippi bordering Illinois was not then a great producer of sport fishes, at least when compared with the Illinois River.

Pike and Pickerel

ESOCIDAE

Pike are often referred to by Midwest fishermen as pickerel. In the Mississippi River a species of pickerel, as well as the pike (*Esox lucius*), was taken in the test nets. The grass pickerel (*Esox vermiculatus*) seldom attains a length over 15 inches. This little pickerel was taken in the test-net collections only at the Grafton station and it is of no importance as either a commercial or sport fish.

Pike, popularly known as northern pike, did not appear in the test-net collections below the station at New Boston, where a single specimen weighing 3.49 pounds was taken. The absence of pike in the collections below this station substantiates the statement of Coker (1930:214) that Keokuk, which is 69 miles below New Boston, "is evidently south of the common range of the true pike in the Mississippi River." More than 91 per cent of the pike taken during the entire survey were caught at the four uppermost 1946 sampling stations.

Commercial fishery statistics suggest that the pike has not been common in the Missouri section of the Mississippi River for at least a half century. In 1894 pike represented 0.01 per cent of the total Missouri commercial catch from the Mississippi, and no pike was reported for the year 1899, table 8. In the Illinois section of the Mississippi, the pike was rather common in the commercial catch for 1894 and 1899. In the Iowa section, the catch of pike by commercial fishermen amounted to 25,042 pounds in 1899. Forbes & Richardson (1920:209), writing nearly a half century ago, stated that the number of pike had greatly decreased in Illinois waters during the previous 25 years.

The taking of pike is now restricted in the Caruthersville-Dubuque section of the river to sport fishing, and the species is too scarce in this section, other than in

the upper part, to be of much importance even as a sport fish.

Perches

PERCIDAE

Three species of sport fishes belonging to the perch family have been reported to occur in the Mississippi River. The yellow perch, *Perca flavescens* (Mitchill), according to Forbes & Richardson (1920:227), is essentially a lake fish but occurs also in running water, most abundantly in the larger rivers. Townsend (1902:684, 721) gave the 1899 commercial take of the yellow perch from the Mississippi River by Illinois fishermen as 1,521 pounds and by Iowa fishermen as 9,665 pounds. He did not report a yield of perch for the Missouri section of the river. Coker (1930:204) wrote several years later that the yellow perch was apparently not common in the vicinity of Keokuk, but suggested that it might become more abundant in the impoundment at Keokuk since it is "essentially a lake fish." He reported that the expected increase had not occurred up to 1926.

In the Caruthersville-Dubuque survey not a single specimen of yellow perch was taken. This fish is usually not considered "net shy" and it appears that if the species occurred in numbers in the parts of the river investigated at least a few specimens would have been netted. Although the yellow perch formerly occurred abundantly enough in the Iowa section of the Mississippi to be of some value commercially, the draining of bottomland lakes and backwaters in the valley may have had the effect of reducing the population. These former lakes probably abounded in aquatic vegetation and, according to Greene (1935:162), one of the most potent ecological factors in the distribution of the yellow perch is aquatic vegetation, a usual necessity for successful spawning. Large perch populations frequently are associated with extensive sandy shoals, and silting of such areas may limit the numbers of perch.

The pikeperches are of some importance to the sport fishery of the Mississippi River, and large catches of these fishes are not uncommon from the upper part of the D-MR section of the river. Experienced anglers usually make their catches in the fall. In

Table 21.—Length-frequency distribution of the sauger and the yellow pikeperch in test-net collections from the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, in 1944 and 1946.

TOTAL LENGTH IN INCHES	SAUGER			YELLOW PIKEPERCH	
	MR-C Section 1944	D-MR Section 1944	D-MR Section 1946	D-MR Section 1944	D-MR Section 1946
8.8-9.7	—	—	4	—	3
9.8-10.7	—	—	1	—	2
10.8-11.7	2	1	9	—	—
11.8-12.7	5	1	9	—	5
12.8-13.7	9	10	13	—	1
13.8-14.7	4	7	17	—	1
14.8-15.7	1	13	11	1	—
15.8-16.7	—	14	4	—	1
16.8-17.7	—	—	—	—	—
17.8-18.7	—	—	—	—	1
18.8-19.7	—	—	—	—	—
19.8-20.7	—	—	—	—	—
20.8-21.7	—	—	—	—	—
21.8-22.7	—	—	—	1	—
22.8-23.7	—	—	—	—	2
23.8-24.7	—	—	—	—	—
24.8-25.7	—	—	—	—	1
Total number	21	46	68	2	17
Average length	13.1	14.8	13.3	18.8	14.3

those sections of the Mississippi surveyed, two species of pikeperches were taken, namely, sauger (*Stizostedion canadense*) and yellow pikeperch, known also as wall-eye (*S. vitreum vitreum*). The sauger was much more abundant in the Caruthersville-Dubuque section of the river than the yellow pikeperch. In the Caruthersville-War-saw section 67 specimens of sauger were taken as compared with only 2 specimens of yellow pikeperch. The yellow pikeperch did not occur in any of the collections from the MR-C section. In the Burlington-Dubuque section the sauger continued to be more abundant than the yellow pikeperch. From this section of the river 68 saugers and 17 yellow pikeperches were taken. According to Coker (1930:204), the sauger was evidently much more common than the yellow pikeperch at Keokuk 20 or more years ago. On the basis of the distribution and abundance of the pikeperches it appears that the sauger is much more tolerant of turbid waters than the yellow pikeperch.

Table 21 indicates that the sauger is usually smaller than the yellow pikeperch. The largest yellow pikeperch taken during the survey was 24.9 inches in length and weighed 6.25 pounds.

Black Basses and Other Sunfishes

CENTRARCHIDAE

The black crappie (*Pomoxis nigromaculatus*) and the white crappie (*Pomoxis annularis*) were the most abundant sunfishes taken in the survey. Crappies were taken at all but three of the stations; however, they were much more common in the D-MR section than in the section below, Appendix B. In the MR-C section crappies accounted for only 5.1 per cent of the total number of all fishes caught in test nets, whereas in the lower D-MR section, that part surveyed in 1944, crappies represented 25.8 per cent of the total test-net catch. In the Burlington-Dubuque section, surveyed in 1946, crappies accounted for 33.0 per cent of all fishes in the test-net collections. The abundance of the crappies relative to the other species of sport fishes is expressed graphically in fig. 15. It may be seen from this graph that at the majority of the stations crappies were more abundant in the collections than all the other sport fishes combined. At the stations where other sport fishes predominated, there were only small total catches of sport fishes. Usually at such stations the sauger and white bass domi-

nated the sport fish catch. In the MR-C collections the black crappie appeared to be slightly more abundant than the white. In the 1944 D-MR collections, the black crappie was almost twice as abundant as the white; however, the dominant black crappie populations were confined to the station just above the mouth of the Missouri River, the next station upstream, which is Grafton, and Cincinnati Landing. At the last of these stations only 7 crappies were taken, a number too small to be of any significance. At Grafton the black crappie was extremely abundant as compared with the white. At Winfield, the next station upstream from Grafton, the crappie population was predominantly white. This dominance of white crappies continued at the remaining upper river stations in 1944 and 1946 with the exception of Cincinnati Landing.

Hansen (1951:224), in his study of the biology of the white crappie, observed that crappie samples taken in hoop nets did not necessarily indicate the relative abundance of the two species. At Lake Chautauqua, near Havana, Illinois, he found that a dominance of black crappies or white crappies shifted in an erratic manner from week to week. In view of Hansen's study, the actual status of the species of crappie that is dominant in the test nets of a given section of river becomes uncertain. However, the constant dominance of the black crappie in catches during the three sampling periods at Grafton tends to substantiate the belief that it is more abundant there than the white. The dominance of the white crappie in most of the upper river collections between Winfield and Dubuque (1944 and 1946) indicates that this species is probably more abundant than the

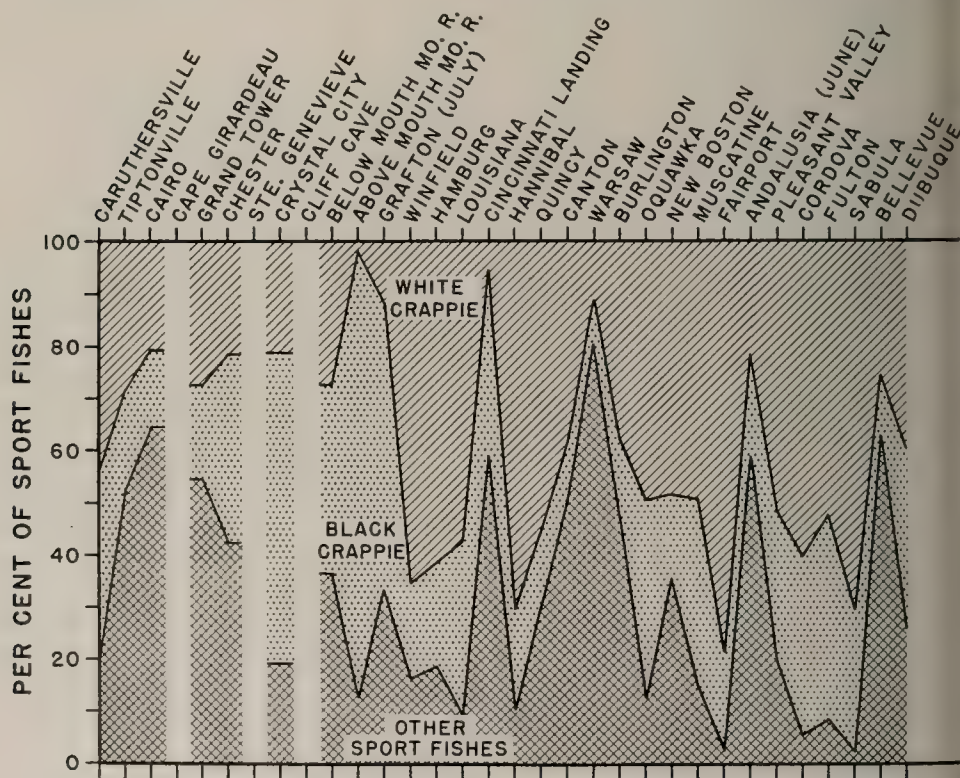


Fig. 15.—The relative abundance, as determined by test-netting, of the white crappie, black crappie, and other sport fishes at the various field stations on the Mississippi River between Caruthersville and Dubuque, 1944 and 1946. The percentages are based on the total number of sport fishes taken at each station. No sport fishes were taken at Cape Girardeau nor at Cliff Cave. The number taken at Ste. Genevieve, two, was considered too small to be significant.

Table 22.—Length-frequency distribution of the black crappie and the white crappie in test-net collections from the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, in 1944 and 1946.

TOTAL LENGTH IN INCHES	BLACK CRAPPIE			WHITE CRAPPIE		
	MR-C Section 1944	D-MR Section 1944	D-MR Section 1946	MR-C Section 1944	D-MR Section 1944	D-MR Section 1946*
2.8- 3.7.....	—	—	56	—	—	32
3.8- 4.7.....	—	3	257	1	7	463
4.8- 5.7.....	1	21	149	—	40	394
5.8- 6.7.....	41	121	142	21	148	212
6.8- 7.7.....	48	291	217	37	191	239
7.8- 8.7.....	18	369	194	34	219	392
8.8- 9.7.....	11	418	288	17	147	446
9.8-10.7.....	4	145	128	4	100	358
10.8-11.7.....	—	21	16	3	24	152
11.8-12.7.....	—	2	3	2	3	33
12.8-13.7.....	—	1	1	—	—	4
13.8-14.7.....	—	—	1	—	—	—
Total number.....	123	1,392	1,452	119	879	2,725
Average length.....	7.3	8.4	7.1	7.9	8.0	7.5
Per cent 8 inches or more.....	26.8	68.7	43.5	50.4	56.1	50.8

* D-MR 1946 data include 51 white crappies from a catch with a 1½-inch hoop net by J. S. Barnett, a commercial fisherman at Oquawka, Illinois.

black in the D-MR section. Coker (1930: 202) found the white crappie was apparently about three times as abundant as the black at Keokuk.

The length-frequency distributions of the black crappies and white crappies taken in the test nets are presented in table 22. Slightly more than 50 per cent of the white crappies taken were 8 inches or more in length; with the exception of individuals taken in the 1944 D-MR section, a smaller proportion of the black crappies were of these lengths. Age and growth studies made from the scales of these fishes showed that the white crappies grew faster than the blacks, which probably accounts for the greater percentages of large white crappies.

It is difficult to determine the abundance of the largemouth black bass (*Micropterus salmoides*) from net and seine collections. As anyone who has attempted the netting of this bass realizes, it is not easily taken in numbers even where a large population may be present. Therefore, very little can be said regarding the status of the largemouth in the river. In the poisoning censuses of fish populations made in backwaters adjoining the Mississippi at Oquawka and Savanna, the largemouth population was rather low. Since these

censuses pertain to only two localities, they do not necessarily indicate the overall status of the bass population. The largemouth black bass formed only an insignificant part of the test-net collections in the MR-C section in 1944 and of those in the D-MR section in 1946. In the D-MR section in 1944 the largemouth amounted to 1.4 per cent of the total number of fishes caught. Of these, 76.4 per cent were taken at Grafton. As was stated previously, some of the nets were set in bottomland lakes and sloughs of the Grafton area, long known as excellent for bass fishing. Anglers usually fish for bass in backwater lakes and sloughs of the Mississippi rather than in the river proper.

As shown in table 23, the average length of largemouth black bass taken in the test-net collections was more than 10 inches.

In each year of the survey, two spotted black bass (*Micropterus punctulatus*) were taken in the collections. This species of bass is too scarce in the Caruthersville-Dubuque section of the river to be of any importance to the sport fishery. The 1944 specimens were taken at Caruthersville and the 1946 at Fulton, Illinois.

No specimen of the smallmouth black bass (*Micropterus dolomieu*) was taken

in the test-net collections; however, one small specimen was taken with a minnow seine at Claryville, Missouri. The absence of this species from the test-net collections indicates that it is probably scarce in the area investigated, and that the largemouth is the only representative of the black basses that occurs in large enough numbers to be of any importance to the sport fishery.

The green sunfish (*Lepomis cyanellus*) appeared to be quite scarce in the Mississippi. In 1944, 18 fish of this species were taken in the test-net collections at

Tiptonville and Crystal City, both MR-C stations. Only 3 were taken in test nets in the D-MR section in 1946. Green sunfish were taken in minnow seine collections at Louisiana, New Boston, Sabula, and Muscatine.

The orangespotted sunfish (*Lepomis humilis*) was not taken in the test-net collections; however, it was taken in minnow seine collections at Grafton and Warsaw. This species seldom attains a length of over 4 inches (Eddy & Surber 1947: 237) and it consequently has little value as a sport fish.

The flier (*Centrarchus macropterus*), according to Forbes & Richardson (1920: 242), is southern in distribution, "occurring in lowland streams and bayous of the lower Mississippi Valley, and in the south Atlantic region from Florida to Virginia." In the Mississippi survey one specimen of this species was taken in a minnow seine haul at Caruthersville and another in a test-net collection at Cairo. This species, like the orangespotted, does not attain a sufficient size to make it of much value as a sport fish.

The bluegill (*Lepomis macrochirus*) was taken at the majority of the survey stations. This species was collected in greater abundance in the D-MR section than in the MR-C. The largest collections of bluegills were taken at Grafton and Dubuque.

The average size of the bluegills collected, as shown in table 24, was over 6 inches. Such a size is usually considered by midwestern anglers as fair for bluegills. Age and growth studies on bluegills collected during the survey show that, on the

Table 23.—Length-frequency distribution of the largemouth black bass in test-net collections from the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, in 1944 and 1946.

TOTAL LENGTH IN INCHES	MR-C SECTION 1944	D-MR SECTION 1944	D-MR SECTION 1946
6.8-7.7	1	1	—
7.8-8.7	1	2	1
8.8-9.7	1	3	1
9.8-10.7	1	15	1
10.8-11.7	2	22	4
11.8-12.7	3	40	3
12.8-13.7	—	17	3
13.8-14.7	1	7	3
14.8-15.7	—	8	—
15.8-16.7	—	6	—
16.8-17.7	—	—	2
17.8-18.7	—	2	—
Total number	10	123	18
Average length	10.9	12.4	12.6

Table 24.—Length-frequency distribution of the bluegill in test-net collections from the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, in 1944 and 1946.

TOTAL LENGTH IN INCHES	MR-C SECTION 1944	D-MR SECTION 1944	D-MR SECTION 1946
2.8-3.7	—	—	6
3.8-4.7	6	11	60
4.8-5.7	5	87	59
5.8-6.7	20	231	75
6.8-7.7	7	204	75
7.8-8.7	—	23	33
8.8-9.7	—	—	—
9.8-10.7	1	—	—
10.8-11.7	—	—	—
Total number	39	556	308
Average length	6.1	6.5	6.1

Table 25.—Length-frequency distribution of the warmouth in test-net collections from the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, in 1944 and 1946.

TOTAL LENGTH IN INCHES	MR-C SECTION 1944	D-MR SECTION 1944	D-MR SECTION 1946
3.8-4.7	1	—	—
4.8-5.7	2	4	3
5.8-6.7	6	23	—
6.8-7.7	5	25	3
7.8-8.7	1	—	4
Total number	15	52	10
Average length	6.5	6.7	7.1

average, 6-inch fish were about 3 years of age, indicating rather slow growth.

The warmouth (*Chaenobryttus cornarius*), according to Coker (1930:204), was never very abundant in the Keokuk area of the Mississippi. This species was not taken abundantly anywhere during the Caruthersville-Dubuque survey. As in the case of the other sport fishes, the warmouth was taken more abundantly in the D-MR collections than in the collections farther south. It was taken less abundantly in the Burlington-Dubuque section than in the lower part of the D-MR section, that part surveyed in 1944.

Age and growth studies of specimens taken from the Illinois-Missouri section of the Mississippi in 1944 tended to show that growth of the warmouth, table 25, was a little slower than that of the bluegill. Bluegills 3 years of age averaged 6.64 inches, whereas warmouths of this age averaged 6.16 inches. The warmouth is probably not abundant enough in the Caruthersville-Dubuque section of the river to be considered of much importance to the sport fishery.

Sea Basses

SERRANIDAE

The white bass (*Lepibema chrysops*) and the yellow bass (*Morone interrupta*) are the only members of this large family, principally composed of marine fishes, occurring in the Caruthersville-Dubuque section of the Mississippi River. The white bass, according to Greene (1935:160), is more northern in range than the yellow bass. In this survey both species were taken at the lowermost station, Caruthersville, and only the white bass in the Dubuque collections; however, one specimen of yellow bass was taken at Bellevue, 17 miles below Dubuque, indicating that the species probably occurs at the geographic extremes of this survey. The test-net collections indicate that the white bass is more widely distributed than the yellow bass in that part of the river surveyed.

The white bass was taken in greater numbers than the yellow bass in the MR-C section of the river; however, neither species was common there. In the D-MR section both species were much more

abundant than in the MR-C section, Appendix B. The white bass accounted for 2.19 per cent of the total number of all fishes in the 1944 D-MR collections, the yellow bass for 0.05 per cent. In the total catch at the stations fished in 1946, the yellow bass was one and one-half times as abundant as the white bass. This reversal in abundance was due to the large catch of yellow bass at New Boston, where 84.1 per cent of the 1946 catch of this fish was taken. One wing net (1-inch mesh) in a backwater area at New Boston produced 198 yellow bass, amounting to 91.2 per cent of the 217 yellow bass caught at this station. Sex determinations made of these fish revealed that 96.5 per cent were ripe males. From this catch it appears that the males possibly are attracted during the spawning season by a few ripe females in the net. A more nearly accurate picture of abundance and distribution of white bass and yellow bass in the D-MR section can be obtained when the New Boston figures are omitted from the 1946 data for both species. When this is done the white bass appears to be three times as abundant as the yellow bass. The abundance of these fishes in the upper river has been discussed by several investigators. In 1888 near Quincy, Garman (1890:137) found the white bass more abundant than the yellow bass, and, many years later at Keokuk, Coker (1930:207) found the white bass more common than the yellow bass.

The former status of these fishes in Illinois is discussed by Forbes & Richardson (1920:320). In discussing conditions of about 50 years ago these authors wrote the following regarding the white bass in the Mississippi: "It was formerly much more common than now. We are informed by Mr. H. L. Ashlock that a dozen years ago one could easily get a hundred pounds of it in an afternoon at Alton with a hundred-yard trammel-net, but that it has now almost disappeared." At the same time these authors (1920:321) found the yellow bass about twice as abundant as the white bass in Illinois.

The average sizes of the white bass and the yellow bass in the test-net collections differed only slightly, table 26. The white bass, however, attains greater sizes than the yellow bass. Both of these fishes

Table 26.—Length-frequency distribution of the white bass and the yellow bass in test-net collections from the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, in 1944 and 1946.

TOTAL LENGTH IN INCHES	WHITE BASS			YELLOW BASS		
	MR-C Section 1944	D-MR Section 1944	D-MR Section 1946	MR-C Section 1944	D-MR Section 1944	D-MR Section 1946
3.8-4.7.....	—	—	17	—	—	1
4.8-5.7.....	—	10	23	—	—	3
5.8-6.7.....	2	17	9	—	—	22
6.8-7.7.....	6	30	13	1	—	18
7.8-8.7.....	5	25	27	1	1	131
8.8-9.7.....	5	18	19	—	3	68
9.8-10.7.....	—	41	17	—	—	9
10.8-11.7.....	1	24	22	—	—	5
11.8-12.7.....	2	9	10	—	—	1
12.8-13.7.....	1	7	3	—	—	—
13.8-14.7.....	2	9	—	—	—	—
14.8-15.7.....	—	2	2	—	—	—
15.8-16.7.....	—	1	—	—	—	—
Total number.....	24	193	162	2	4	258
Average length.....	9.2	9.4	8.4	7.8	9.0	8.4

are considered as excellent sport fishes, and they often form an important part of the angler's catch.

PREDATORY FISHES

In the present report the gars and the bowfin are grouped as predatory fishes. These fishes feed to a large extent upon other fishes and they have little commercial value. Many of the species designated in this report as commercial or sport fishes are also predatory in habits. The catfishes, black basses, and pikeperches are examples.

Gars

LEPISOSTEIDAE

The shortnose gar (*Lepisosteus platostomus*)* occurred much more frequently in the test-net collections than did the other species of gars. This gar was abundant in the MR-C and D-MR sections of the river.

The longnose gar (*Lepisosteus osseus*) also was common in both sections of the river; however, it occurred much less frequently in the test-net collections than the shortnose gar.

Eighty-five specimens of the alligator

* In this investigation the spotted gar, *Lepisosteus productus* Cope, if present, was not separated from the shortnose gar.

gar (*Lepisosteus spatula*) were taken during the survey. Of these, 84 were from the MR-C section. The single specimen from the D-MR section was taken at Grafton. As shown in Appendix B, table 1, in the MR-C section the alligator gar was netted at only four stations. Eighty of the 84 specimens were taken at Cairo. Forbes & Richardson (1920:35) state that: "The home of the alligator-gar is in the streams of the Gulf of Mexico, from Mexico to Cuba. It ascends the Mississippi above St. Louis, and has occasionally been taken in the lower Illinois River."

The length-frequency distribution of the gars taken in the test-net collections is given in table 27.

The largest gar taken during the survey was an alligator gar measuring 5 feet 5 inches total length and weighing 54.81 pounds. This specimen was taken in a 1-inch-mesh wing net at the Grand Tower station. The alligator gar, according to Dr. David Starr Jordan, reaches a length of 20 feet (Forbes & Richardson 1920:35). The average length of the alligator gar in the MR-C collections was 23.5 inches, an average less than that determined for the longnose gar. The shortnose gar, as shown in table 27, averaged much less in length than the other gars.

In some areas gars are sought by anglers merely for sport. The larger specimens,

particularly of alligator gars, provide a challenge to an angler using only moderately heavy tackle.

Bowfin

AMIIDAE

The bowfin in the Midwest is considered by some anglers as an excellent sport fish. This fish will, on occasion, strike a spinner-bucktail combination or

a plug. The vicious runs of the bowfin after striking an artificial lure are something to be remembered, even by the experienced angler. The value of the bowfin as a food fish seems to be a debatable subject; however, the smoked flesh of a bowfin is considered a delicacy by some.

Fewer bowfins were taken in the collections from the MR-C section than in those from the D-MR section of the river. Catches of 41 bowfins at Winfield and 62

Table 27.—Length-frequency distribution of the gars and the bowfin in test-net collections from the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, in 1944 and 1946.

TOTAL LENGTH IN INCHES	SHORTNOSE GAR			LONGNOSE GAR			ALLIGATOR GAR		BOWFIN			
	MR	C	D-MR	MR	C	D-MR	MR	C	MR	C	D-MR	D-MR
	Sec. 1944	Sec. 1944	Sec. 1946	Sec. 1944	Sec. 1944	Sec. 1946	Sec. 1944	Sec. 1944	Sec. 1944	Sec. 1944	Sec. 1944	Sec. 1946
6 8-7 7	—	—	—	—	1	—	—	—	—	—	—	—
8 8-9 7	—	1	—	—	—	—	—	—	—	—	—	—
11 8-12 7	1	—	—	—	—	—	—	—	1	—	—	—
12 8-13 7	7	—	—	—	—	—	—	—	1	—	—	—
13 8-14 7	53	8	—	—	—	—	—	—	2	1	1	—
14 8-15 7	116	52	—	1	—	—	—	1	—	3	1	—
15 8-16 7	108	87	9	—	—	—	—	—	3	4	3	—
16 8-17 7	51	102	6	2	2	1	—	—	4	11	5	—
17 8-18 7	38	123	7	2	16	1	—	—	2	8	6	—
18 8-19 7	32	119	30	2	20	1	2	—	4	12	20	—
19 8-20 7	18	109	32	2	8	3	3	—	8	14	32	—
20 8-21 7	37	91	45	2	7	1	7	—	2	5	34	—
21 8-22 7	26	59	33	2	6	3	26	—	1	9	24	—
22 8-23 7	36	29	26	—	13	1	19	—	—	3	12	—
23 8-24 7	33	19	15	—	7	5	14	—	—	2	5	—
24 8-25 7	26	5	4	1	11	6	7	—	—	4	5	—
25 8-26 7	11	1	1	—	13	1	3	—	—	1	3	—
26 8-27 7	8	3	1	2	4	2	1	1	—	1	3	—
27 8-28 7	1	1	—	1	5	3	—	—	—	2	—	—
28 8-29 7	—	—	—	4	3	3	—	—	1	1	—	—
29 8-30 7	—	—	—	2	6	1	—	—	—	—	—	—
30 8-31 7	—	—	—	—	3	1	—	—	—	—	—	—
31 8-32 7	—	—	—	6	1	—	—	—	—	—	—	—
32 8-33 7	—	—	—	1	1	—	—	—	—	—	—	—
33 8-34 7	—	—	—	3	2	—	—	—	—	—	—	—
34 8-35 7	—	—	—	4	3	1	—	—	—	—	—	—
35 8-36 7	—	—	—	4	2	—	—	—	—	—	—	—
36 8-37 7	—	—	—	2	1	—	—	—	—	—	—	—
37 8-38 7	—	—	—	1	—	—	—	—	—	—	—	—
38 8-39 7	—	—	—	—	1	—	—	—	—	—	—	—
39 8-40 7	—	—	—	2	2	2	—	—	—	—	—	—
40 8-41 7	—	—	—	3	3	—	—	—	—	—	—	—
41 8-42 7	—	—	—	—	—	—	—	—	—	—	—	—
42 8-43 7	—	—	—	1	1	—	—	—	—	—	—	—
43 8-44 7	—	—	—	—	1	—	—	—	—	—	—	—
44 8-45 7	—	—	—	—	—	—	—	—	—	—	—	—
45 8-46 7	—	—	—	1	—	—	—	—	—	—	—	—
46 8-47 7	—	—	—	—	—	1	—	—	—	—	—	—
50 8-51 7	—	—	—	—	—	1	—	—	—	—	—	—
64 8-65 7	—	—	—	—	—	—	1	—	—	—	—	—
Total number	602	809	209	51	143	38	84	1	29	81	154	—
Average length	18.5	19.1	21.1	30.6	24.8	27.1	23.5	—	18.7	20.3	21.1	—

Table 28.—Length-frequency distribution of the goldeye, the mooneye, and the gizzard shad in test-net collections from the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, in 1944 and 1946.

TOTAL LENGTH IN INCHES	GOLDEYE	MOONEYE		GIZZARD SHAD	
	D-MR Section 1946	D-MR Section 1946	MR-C Section 1944*	D-MR Section 1944	D-MR Section 1946
2.8-3.7.....	—	—	—	7	1
3.8-4.7.....	—	—	1	9	26
4.8-5.7.....	2	31	3	35	72
5.8-6.7.....	18	22	24	12	13
6.8-7.7.....	12	52	21	27	7
7.8-8.7.....	8	38	31	50	26
8.8-9.7.....	7	19	32	35	28
9.8-10.7.....	7	9	43	86	22
10.8-11.7.....	12	2	28	146	8
11.8-12.7.....	2	1	28	184	6
12.8-13.7.....	2	—	23	126	8
13.8-14.7.....	5	—	18	62	10
14.8-15.7.....	6	—	6	22	4
15.8-16.7.....	—	—	5	4	6
16.8-17.7.....	3	—	1	—	—
Total number.....	84	174	264	805	237
Average length.....	9.7	7.4	10.3	11.2	8.0

* The goldeye was not separated from the mooneye at all of the 1944 stations and was included with the mooneye in the 1944 data.

at Fulton were the largest taken at any of the stations. Both of these stations were in the D-MR section. The average lengths of the specimens taken in the test-net collections are shown in table 27.

FORAGE FISHES

The forage fishes are of little or no commercial value, but they serve as food for other fishes. They are usually very numerous as compared with the predatory fishes that feed upon them. Minnows (Cyprinidae) and the gizzard shad (*Dorosoma cepedianum*) are quite abundant in the Mississippi River and undoubtedly serve as food for many of the carnivorous fishes. The term forage fishes as applied here is not particularly satisfactory since the specimens caught in nets were too large to serve as prey for all but very large carnivorous fishes.

The various species of minnows taken during the survey were caught in most cases with a minnow seine; catches with this gear are not considered in this paper.

The goldeye (*Amphiodon alosoides*) and the mooneye (*Hiodon tergisus*), included with the forage fishes in 1944 and

with the commercial fishes in 1946, Appendix B, lack commercial importance in the MR-C section and parts of the D-MR section. The goldeye was not separated from the mooneye at all the 1944 stations and was included with the mooneye in the 1944 data, Appendix B, table 1. In the 1946 survey these two species were separated, table 15 and Appendix B, table 2. The mooneye was taken in much greater abundance than the goldeye in the 1946 collections. These two species formed a more important part of the catch in the Burlington-Dubuque section of the river than they did in the parts of the river fished in 1944. The length-frequency distribution of the goldeye and mooneye is given in table 28. As indicated by this table the goldeyes were of larger sizes than the mooneyes. Neither of these species was collected in sufficient numbers to indicate that they are of potential importance as commercial fishes in the Caruthersville-Dubuque section of the river.

Only two specimens of the golden shiner (*Notemigonus crysoleucas*) were taken in the test-net collections. They were collected in 1944 at Grafton.

The gizzard shad formed a much more important part of the test-net catch in 1944 than it did in 1946. Along with the drop in the 1946 catch of gizzard shad, table 28, there was also a noticeable reduction in size of these fish. In two backwater areas poisoned in 1946, near Savanna, there were low populations of gizzard shad; only 196 individuals per acre and an average of 4.69 pounds per acre were recovered. Two similar backwater areas poisoned in 1947, near Oquawka, contained a per acre average of 8,201 gizzard shad that in the aggregate weighed 284.5 pounds.

The gizzard shad is so bony that it is seldom used as a food fish by man; however, when small it is considered as an important link in the food chain of other fishes.

The skipjack (*Pomolobus chrysochloris*) was taken occasionally in the collections between Caruthersville and Warsaw. No specimen was collected above Warsaw. Coker (1930:169) noted that during the first few years following construction of the power dam at Keokuk the abundance of the skipjack declined rapidly in the upper part of the river. He presented evidence to show that the skipjack is migratory but does "not necessarily go to extreme northern or extreme southern waters, and that the breeding places from which the upper river was formerly chiefly stocked are no longer accessible to a great number of herring (skipjack)." Eddy & Surber (1947:91) state that the skipjack is very rare, if not extinct, above the Keokuk dam. The scarcity of the skipjack in the collections of the 1944 survey tends to indicate that this fish may have been affected by the locks and dams constructed below Keokuk since the time Coker made his studies on the river.

The skipjack is too bony to be of much value as a food fish; however, it is considered by some anglers as a very gamy fish when taken on light tackle. The importance of the skipjack, according to Coker (1930:166), is as a host for the young (glochidia) of the niggerhead mussel. This mussel was formerly of great economic importance to the button industry, but appeared to decline in abundance with the decrease of the skipjack in the upper river.

DISCUSSION

Poor land management in the upper Mississippi drainage basin has changed the section of the river from Dubuque to the mouth of the Missouri from a clear to a coffee-colored stream in less than a century. With the promotion of drainage schemes under the guise of agricultural development, the Mississippi River was leveed out of most of its natural flood plain reservoirs, which were evidently once the spawning and rearing grounds of many fishes. This encroachment upon the flood plain of the river by man, combined with intensive agricultural practices in the uplands, has brought about many of the present flood control problems. The canalization of the upper river evidently is responsible for the disappearance or reduction in numbers of certain fishes and has produced fisheries problems associated with draw-downs and silt-laden navigation pools. City and manufacturers' wastes also have contributed to the deterioration of the river as a fish habitat.

Although commercial fishing may have contributed to the reduction of certain fishes, the decline in the fishery as a whole appears to have followed the change in habitat rather than any intensification of commercial fishing activities. Such findings given in this paper as pertain to the abundance, size, and maturity age of the important commercial and sport fishes may be of some value in developing fishing regulations that are biologically sound. However, the problem of the Mississippi River fishery is more than one of legal restrictions. Perhaps legal restrictions will aid some species, but, with an environment that is unfavorable, other species probably will continue to dwindle. The decline in the catch of the buffalofishes, catfishes, pike, sturgeons, paddlefish, and others has been pointed out. The future of the paddlefish and the blue sucker appears in doubt. The status of the freshwater eel and the skipjack has been seriously affected, probably by the installation of locks and dams in the upper river. Perhaps other fishes have been and will be affected by the dams.

The differences in the abundance of fishes in the several parts of the pools, as evidenced by the 1946 test-net collections,

clearly demonstrate the effect canalization has on the habitat in the river. Evidently the silt-covered bottoms and reduced currents observed in the lower and middle reaches of the pools are less favorable for many species, particularly of the sport fishes, than conditions existing in the upper reaches. On the other hand, some of the impoundments have provided more backwater areas, which are usually considered favorable to fish production. The inundation of forest land has resulted in the formation of habitat containing hollow logs, suitable for catfish spawning.

The MR-C section of the river appeared to be much less productive of fish than the D-MR section. Greater scarcity of spawning grounds, turbidity of water, and swiftness of current in the MR-C section, as compared with the D-MR section, appear to be factors accounting for some of the productivity differences of the two sections. These factors are reflected in the distribution and abundance of sport fishes in the test-net collections.

Since the end of the last century the catch of carp has annually compensated for some of the losses in poundage of declining species. Commercial values of carp, however, are not so high as those of some of the declining species. Some of these losses might be compensated for if proper utilization could be made of certain abundant species in the river. Crappies, particularly the white, are quite abundant in the D-MR section of the river. Probably only a small portion of these fishes are taken annually by anglers. Crappies are not a long-lived fish, and as a result most of this resource is lost. The commercial fishery would benefit if crappies were placed on the commercial list, since these fishes are netted easily and would bring a good price. It is doubtful if commercial fishing would deplete the crappie population to such an extent that the sport fishery would suffer. Reduced crappie populations might permit better growth and furnish anglers with larger fish than are now being taken.

Development of better methods for handling river carpsuckers in warm months would benefit commercial fishermen.

The smoking of carp and bowfins has possibilities of further increasing values of these fishes.

Poor fishing in some instances may be a result of the decrease in natural predators (Bennett 1947:278). In the Mississippi River gars may be important predators. These fishes are possibly filling a gap left by the decreases in populations of pike, yellow pikeperch, and fish-eating ducks. Further biological studies on gars might establish the possibility that gars are beneficial to the fishery rather than harmful, as is commonly believed by fishermen.

SUMMARY

1. A survey of the fishes occurring in the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa, was made in 1944 and 1946. Thirty-one sampling stations were used. The following types of commercial fishing gear were employed: 25-foot *Common Sense* minnow seines, 100-yard trammel nets, 100-yard seines, hoop nets, wing nets, trap nets, basket traps, and trotlines.

2. The lengths and weights of fishes and the condition of their gonads were recorded afield for all individuals captured in the test nets. The length-frequency distribution of the more abundant fishes was recorded in tabular form. Altogether 26,037 fishes having a total weight of 28,294.25 pounds were taken in the 1944 and 1946 operations.

3. Observations on the various species of fishes taken by test netting were recorded. The numbers and weights of fishes caught at each station were listed by species, Appendix B.

4. Characteristics of the Mississippi River and the sampling stations were studied. Comparisons were made, in relation to the habitat and fishery, between two sections of the Mississippi River: one extending from Dubuque to the mouth of the Missouri River (D-MR section) and the other from the mouth of the Missouri to Caruthersville (MR-C section).

5. The carp, freshwater drum, flat-head catfish, channel catfish, carpsuckers, smallmouth buffalo, shortnose gar, longnose gar, and gizzard shad were taken abundantly from both sections of the river.

6. The blue catfish, alligator gar, black bullhead, and black buffalo were collected principally in the MR-C section.

The alligator gar was taken only once in the D-MR section.

7. Sport fishes, bigmouth buffalo, and channel catfish were taken more abundantly in the D-MR section than in the other section.

8. Carp, buffalofishes, catfishes, carp-suckers, and freshwater drum were the most abundant commercial fishes taken during the survey. The shovelnose sturgeon was found to be the only sturgeon still abundant enough in the river to be of any commercial importance. The paddlefish was much less common than formerly.

9. The blue sucker, skipjack, and American eel were not numerous at any of the sampling stations. The skipjack was not taken above Warsaw, Illinois.

10. The crappies were the most abundant game fishes in the test-net collections. The black crappie was taken more abundantly than the white between the mouths

of the Illinois and Missouri rivers. Above the mouth of the Illinois the white crappie was taken more abundantly than the black. The bluegill was second in abundance to the crappies among the game fishes. The sauger was collected in greater abundance than the yellow pikeperch (walleye). The yellow pikeperch was not taken in the MR-C section. No specimen of yellow perch was taken, although old records list this species as once fairly common in the sections of the river surveyed. White bass were more abundant than yellow bass.

11. Fishes, particularly game fishes, were collected more abundantly in the upper reaches of the navigation pools than in the middle and lower reaches.

12. The principal factors limiting the Mississippi River fishery are related to soil erosion of the watershed, levee and drainage works, and industrial and municipal pollution.

APPENDIX A

MISSISSIPPI RIVER FIELD STATIONS

BELOW are descriptions of the Mississippi River field stations at which test-net fishing was done in 1944 and 1946 between Caruthersville, Missouri, and Dubuque, Iowa.

Following the name of each station is the designation of the section of the river in which the station was located and the dates on which test-net fishing was done at the station. MR-C designates that section of the Mississippi River between the mouth of the Missouri River and Caruthersville; D-MR designates that section between Dubuque and the mouth of the Missouri River.

1.—**Caruthersville, Missouri** (MR-C section, April 6–12, 1944). The river at this station was at flood stage and out of its banks. Nets were set along the Missouri bank of the river wherever possible. Also nets were set in a large levee borrow pit, the water of which, as a result of the flood, was continuous with the water in the main channel. To enter the borrow pits, the powered fishing boat passed over a barbed wire fence without difficulty. Toward the end of the sampling period the river receded, and two nets were set in small streams connecting the borrow pit with the river channel. The river dropped enough to allow making several minnow seine hauls on sand bars near the ferry landing on the Tennessee side of the river. At the time of departure of the fishing boat from Caruthersville the river had again begun to rise.

2.—**Tiptonville, Tennessee** (MR-C section, April 15–May 10, 1944). Here the river was at flood stage, and the flood was considered locally as of major proportions. A small fleet of United States Army Corps of Engineers boats and the Tiptonville ferry were moored in a slough close to the town of Tiptonville and approximately three-quarters of a mile from the river channel. Normally this slough is dry for part of each year. The current at this station was swift. Towboats carrying loaded barges upstream were unable to push their entire complements of barges. Instead they pushed half

their tows to points upstream, where the barges were tied up to trees or other stationary objects; then the towboats returned downstream to pick up the remaining barges.

Because of mechanical difficulties the expedition was delayed here for about 20 days.

It was impossible to set nets in or near the river channel. All sets were made in flooded cornfields or cotton fields or within the margin of woody vegetation adjacent to the river channel. Several of the net sets were made in a flooded slough in which the *Anax* and other boats were moored, and in a temporarily inundated, shallow levee borrow pit. The disparities in habitats fished at this station were too great to make the data comparable to those of other stations. However, it appears logical to assume that fish normally confined to the river channel were distributed temporarily over a large expanse of water. The river was reported unofficially to have been 3 miles wide at Tiptonville during the flood.

3.—**Cairo, Illinois** (MR-C section, May 18–24, 1944). At this station, the water was high but it fell more than 13 feet during 5 days of netting. On the Illinois side of the Mississippi River, levees have been built to protect the city of Cairo. The levees on the Missouri side are some distance back from the river.

Sampling was done on the Illinois side of the Mississippi, 5 to 6 miles above the mouth of the Ohio River, just above Cairo, in shallow water adjacent to and within 50 to 100 yards of the river channel, and in a levee borrow pit. The rapid fall in water level necessitated moving the nets to deeper water nearly every day.

4.—**Cape Girardeau, Missouri** (MR-C section, May 26–31, 1944). Netting was done along both banks of the river just south of Cape Girardeau in an area called Cape Bend. There were several sand islands here, covered mainly with willows, and a number of log jams. Several wing nets with leads were set at the mouth and several 100 yards up the Little River Diversion Canal. This

canal lies at the upper end of a huge drainage system that covers the entire southeast section of Missouri, including the so-called "boot heel."

5.—**Grand Tower, Illinois** (MR-C section, June 2-9, 1944). The river stage was high here, as at Cape Girardeau; however, it is believed that fishing at this station was not so greatly influenced by high water as at stations below Cape Girardeau.

Nets were set along the Grand Tower waterfront and in the chute around the east side of Grand Tower Island. The current in the chute around the island was strong. At normal river stage the flow in the chute around Grand Tower Island is supposed to be much reduced and at times it is cut off entirely.

Because of the narrow constriction in the river channel just above Grand Tower, the current in the main channel (and in the chute around the island during flood stage) is very swift. The Missouri bank of the river at this station is a precipitous rock bluff, and the low flood plain on the Illinois side is subject to flooding even at a moderately high stage of water. Vegetation along the Illinois shore and on the island consists principally of willow and cottonwood. During the work at this station, early in June, typical warm summer weather began.

6.—**Chester, Illinois** (MR-C section, June 11-15, 1944). The river was high during the sampling period at this station. Nets were set in the vicinity of Horse Island at the mouth of Old River and several miles up Old River in the vicinity of Kaskaskia Island. At these locations the current was swift. Some netting was done in quiet backwaters just above Chester and across the river from Menard, Illinois. The Missouri side and Kaskaskia Island are in levee districts. Minnow seining was done in the vicinity of Claryville, Missouri.

7.—**Ste. Genevieve, Missouri** (MR-C section, June 18-24, 1944). Netting was done on both sides of an island almost across the river from Ste. Genevieve. Minnow seining was done in shallow water along the shore line of two islands at Ste. Genevieve. (See section on "Pollution" regarding this station.)

8.—**Crystal City, Missouri** (MR-C section, June 25-30, 1944). The river stage was higher at this station than at Ste. Genevieve. The river was backed up in Platin

Creek enough to provide harbor for a fleet of large quarter boats operated by the United States Army Corps of Engineers.

Fishing operations were carried on in Platin Creek—from 200 to 300 yards from its mouth to about a mile from its mouth—and in the river between Platin Creek and Hug Landing. The mouth of Platin Creek is just below the city limits of Crystal City, and Hug Landing is a mile distant, just above Crystal City. Nets were set along the Missouri shore of the river. Here the bank is low, but steep, and bordered by a narrow margin of willows and cottonwood trees.

At the upper net sets in Platin Creek the water was clear, and aquatic vegetation was present. Because of the high river stage, there was virtually no flow in the creek here. The creek was about 100 feet wide at this upper point and it was nearly bank full. It was well shaded by overhanging trees. Minnow seine hauls were taken in Platin Creek.

9.—**Cliff Cave, Missouri** (MR-C section, July 2-8, 1944). The river stage was high at this station. Netting was carried on between Cliff Cave and White House Creek on the Missouri side of the river and at the mouth of Columbia Creek on the Illinois side. This stretch covered about 4 miles by river channel. Most of the sets were made among small, partially submerged willows. Minnow seining was done around sand bars formed in the river along the Illinois side just below the Jefferson Barracks Highway Bridge and in shallow water along the Missouri side just below the submarine cable crossing.

10.—**Mouth of Missouri River, Missouri** (MR-C and D-MR sections, July 10-15, 1944). The mixing of the waters of the Missouri and the Mississippi rivers presents an impressive sight. As the water of the muddy Missouri billows into the Mississippi it appears like rolling clouds of smoke against a clear sky. The water of the Mississippi is far from clear, but that of the Missouri is so much more turbid that the contrast is quite marked.

Netting was divided into two units at this station. Equivalent numbers of wing nets and hoop nets were operated at two stations, one above and one below the mouth of the Missouri River. The nets operated below the Missouri River were set along the

Missouri shore between the mouth of the Missouri and the Chain of Rocks Bridge. The nets operated in the upstream unit were set along the Missouri shore in the vicinity of Mobile Island. At the time netting operations were begun here, the river was high, nearly bank full. While netting was being done at this station the water receded considerably.

11.—Grafton, Illinois (D-MR section, March 22–30, July 17–25, and September 22–27, 1944). Grafton was used as the key station during 1944. It was the lowermost station in the impounded section of the river. Obviously, certain physical characteristics of the river at Grafton vary considerably from those of the unimpounded river, which begins just below Lock and Dam No. 26 at Alton, Illinois.

At the lower ends of navigation pools in the impounded section, the river assumes some of the characteristics of a lake. It is somewhat comparable in appearance to the MR-C section in flood stage, although it lacks the swift current that usually accompanies flood waters. In the upper few miles of these pools the river appears to have more nearly the characteristics of a large river—somewhat swollen or slightly out of bank but with moderate current velocity. The velocity of the current in the pool is dependent upon the operation of the dam that creates this pool as well as the dam at its upstream reach. The operation of each dam, that is, the position of the gates, depends upon the volume of water to be passed down the river or the amount required for the maintenance of a 9-foot channel for navigation.

Fishing operations at the Grafton station during March were carried on primarily in the sloughs and lakes adjoining the last few miles of the Illinois River. Since the fish habitat in these lakes and sloughs differed widely in appearance from that in the Mississippi River, it is assumed for two reasons that the catch of fish in this area was not typical of that in the Mississippi. First, the water of this area was relatively clear as compared with that of the Mississippi, and, second, the lakes and sloughs had no current, although they were connected directly with the Illinois River channel.

Most of these lakes and sloughs were marked by a tangle of fallen and decaying trees, some by the remaining stumps of

a once dense river-bottom forest. Some were merely enlargements of water areas that were present before the Alton dam was built. Others were bodies of water created by the impoundment.

In March, net sets were made on the Illinois side of the Mississippi River just below the mouth of the Illinois River along the waterfront at Grafton; sets were made on the Missouri side of the river off the northwest shore of Perry Island and in the lower end of the small chute between Perry Island and the mainland. The water-level was at full-pool stage and the current was slow as compared with that of the unimpounded waters below Pool No. 26. Although a definite routine of lifting all the nets each day usually was followed, it became impossible on the Missouri side of the river when for 2 days extremely high winds prevented the lifting of nets there.

In the July sampling period at Grafton, most of the fishing effort was concentrated in the Mississippi River, although some test netting was done in the backwater sloughs and lakes between the Illinois and the Mississippi, in which netting had been done in March. In July, sets were made on the Illinois side of the Mississippi along steep-sided earth banks between Squaw Island and Calhoun Point, and on the Missouri side of the river along the northwest shore of Perry Island and the gently sloping Missouri shore approximately a mile above. The water-level of the area was at full-pool stage. It appeared to be the policy of the Army Engineers to maintain Pool No. 26 at or near full level.

The operations at this station in September were similar to those in July. The net sets were made in approximately the same locations.

12.—Winfield, Missouri (D-MR section, July 27–August 2, 1944). Fishing operations at this station were carried on primarily below Lock and Dam No. 25, although two or three nets were set for several days in the pool above the dam, fig. 2. The nets operated below the dam were set along the east side of Maple Island, on the Illinois side near the Winfield ferry landing, and on the Missouri side in Cuivre Slough, at the upper end and channel side of Turkey Island, and at the mouth of Bobs Creek.

Farm land on the Missouri side of the river in this section is low and is subject to

flooding. It is maintained in an arable condition through a series of drainage districts and levees.

13.—Hamburg, Illinois (D-MR section, August 3–9, 1944). A number of years ago, Hamburg was an important shipping center for Calhoun County apples. It and a great number of other small towns along the river were important during the days of packet steamers when river shipping was the main activity of many of these towns. Now there is virtually no shipping from any of these towns except those having grain elevators located to fill barges. Outside of grain shipping, commercial fishing is probably the only industry associated with the river.

Netting at the Hamburg station was in about the middle of Pool No. 25. Nets were set in Westport Chute, around Kelly Island, in Thomas Chute, and in the mouth of Bryants Creek. The main channel is divided at the head of Westport Island, and part of the flow is carried by the Westport Chute. Although the water is deflected away from Westport Chute by wing dams, it is rather deep there. It carries enough current to allow the operation of hoop nets. Wing nets were set along the west margin of the chute and near the head of Westport Island. The narrow strip of land between Westport Chute and the Elsberry Drainage District Levee was low and swampy and was dissected by several sloughs; the entire area was covered by a dense growth of willow and cottonwood trees. Other net sets were made on the east shore of Westport Island, where the current was moderately swift. The sets around Kelly Island were located over a sandy bottom. Several seine hauls were made on a long, wide sand bar extending in an upstream direction from the head of Westport Island.

An extensive area along the river a few miles above Hamburg is wide river-bottom bordered on the Illinois side by high bluffs. The Illinois bottom area, which lies at the lower end of Sny Island Levee and Drainage District, is dissected by sloughs, backwater lakes, and the Sny. This area was once considered excellent for waterfowl.

14.—Louisiana, Missouri (D-MR section, August 12–17, 1944). This station was located in the middle section of Pool No. 24, fig. 3. Nets were set on the Illinois side of the river below the Alton Railroad bridge and in a cove just above the highway bridge;

on the Missouri side of Blackburn Island, in the mouth of Salt River, and at the lower end of Angle Island. The areas above the railroad and highway bridges were essentially identical. Both were shallow backwaters in the lowland between the Illinois levee and the river channel. Before the construction of Lock and Dam No. 24, the areas were in dense growth of small woody vegetation, but at the time of the survey only stumps remained.

In Salt River the nets were set about one-fourth to one-half mile above its mouth. There was very little flow in the stream in this area.

15.—Cincinnati Landing, Illinois (D-MR section, August 19–23, 1944). Netting operations were carried out here in the upper section of Pool No. 24, within an approximate radius of 2 miles below Lock and Dam No. 22, fig. 4. Nets were set in a slough near Taylor Island. This slough, which carried a moderately swift current, produced the first adult blue sucker taken in 1944. Sets were made also in the narrow neck of water between Cattel Island and the mainland just below the Saverton Dam. The navigation channel shores of these islands consist of heavy sand deposits, which are typical of the channel shores below the locks and dams. Between Cattel and Taylor islands was a broad expanse of water which covered a continuous sandy bottom to a depth ranging from 2 to 3 feet.

16.—Hannibal, Missouri (D-MR section, August 25–30, 1944). Netting operations were carried on here in the vicinity of Glaucous Island, which is about 2 miles above Hannibal. This area is in the middle section of Pool No. 22, 13 miles below Lock and Dam No. 21. Nets were set in the slough between Glaucous Island and the Missouri shore and on the channel side of Glaucous Island. The slough was approximately 150 yards in width and in some places reached a depth of 10 feet or more. At other points it was quite shallow. Along most of the Missouri shore of the slough, the bottom sloped off abruptly into deep water. Some of the sets on the channel side of the island were made in deep water and others in relatively shallow bays. The current here was moderately swift.

17.—Quincy, Illinois (D-MR section, September 2–6, 1944). The Quincy station was located at the upper end of Pool No. 22.

about 3 miles below Lock and Dam No. 21. Nets were set in a slough between two islands (Ward Island and Island No. 432) and the Illinois shore. This slough was typical of river backwaters, having mud banks and shallow water. The river-channel shore, or the west shore, of Ward Island was covered by deposits of sand and protected by a number of wing dams. The current in the river channel opposite Ward Island was quite swift.

Minnow seining was done along the river-channel side of Ward Island, Island No. 432, and a small unnamed island just below 432.

The main pumping station for the South Quincy Drainage and Levee District is located just outside of the levee at the head of Island No. 432. During high river stages, this station pumps water from a network of lakes and drainage ditches on the outside of the levee. It was reported locally that these ditches and lakes furnish good bass and crappie fishing at certain times of the year. During the stay of the survey party here in 1944, this area was fished by a large number of sport fishermen from Quincy.

18.—Canton, Missouri (D-MR section, September 8-13, 1944). This station was located in the upper end of Pool No. 21. Test-netting was done at the head of Canton Chute along the east shore of Island No. 416, in Smoots Chute, and along the west shore of Island No. 416. Several nets were set along the Missouri shore below the Canton waterfront. The water in Canton Chute was quite clear as compared with that of the river channel, and the current in the chute was relatively slow. Canton Chute carries drainage from the Lima Lake Drainage District through Bear Creek diversion channel. While the survey party was at this station, the upper part of Canton Chute was being dredged, apparently for the purpose of facilitating drainage of water from the lowland on the Illinois side.

The upper end of Canton Chute is bordered by low but steep mud banks, which apparently are characteristic throughout its length. The connecting channel between the upper end of Canton Chute and the main stem of the river has a sandy bottom, and the shores of the upper end of Island No. 416 are covered with heavy deposits of sand. The channel into Canton Chute is flanked

on its upstream side by a large, broad sand bar which obstructs the flow of water from the river channel into Canton Chute. The upper end of Island No. 416 is only a little more than a mile below Lock and Dam No. 20, and, as with similar formations in the upper reaches of other pools, the islands and shore line are characterized by deep deposits of sand. In fact, some of the islands are nothing more than large sand bars. The wing dams opposite the west shore of Island No. 416 are permanent rock structures. It appears that, in the canalized section of the river, the temporary wing dams constructed of piling are being replaced with permanent rock structures. Since it seems to be characteristic of the temporary wing dams in the lower river to collect great piles of driftwood that tend to create deep water holes just downstream from these dams, it might be that the temporary structures offer cover for fishes which the permanent ones do not. Large deposits of sand were found near the permanent structures, but no driftwood. The water flows between the piles of the temporary dams, while it is completely deflected around the permanent ones. Consequently, driftwood is washed away from the permanent dams but is pinned against and above the temporary ones by the force of the current.

19.—Warsaw, Illinois (D-MR section, September 14-19, 1944). This was the uppermost point on the river studied in 1944. Here netting operations were conducted in the upper part of Pool No. 20: along the Iowa border in the vicinity of the mouth of the Des Moines River and around Island No. 404 above the city of Warsaw; along the Missouri border below Alexandria and in the upper end of the slough between Fox Island and the mainland.

The current was quite sluggish near the mouth of the Des Moines River. The Mississippi from just above the mouth of the Des Moines to the head of Fox Island is confined by steep mud banks, which are protected from erosion by riprapping at several places. The shore line of Island No. 404 and the islands below Keokuk Dam (Lock and Dam No. 19) are covered with deep deposits of sand. The slough between Fox Island and the Missouri mainland carries a moderately swift current and is bordered on both sides by mud banks.

The upper end of Pool No. 20 is subject

to daily fluctuations of approximately 12 inches resulting from the operation of the Keokuk Dam, which, with its hydroelectric plant, was constructed by the Union Power and Light Corporation. Power produced at Keokuk is used to supplement production at other plants, and this plant is operated only during the day. Consequently, at the end of a day's operation, when the turbines are shut off, the flow of water through the dam is decreased, and the water level in the upper part of Pool No. 20 recedes. Operations at the dam are resumed daily, and by noon the water level in Pool No. 20 has again reached the maximum of the previous day. While this daily fluctuation may not affect the fish population, it does, however, affect the method of fishing. Coker (1914, 1929, 1930) made detailed studies of the effects this dam has had on the local fishery at Lake Keokuk, Pool No. 19.

An earlier discussion of the Warsaw station is included under the section titled "Pollution."

20.—Burlington, Iowa (D-MR section, April 10–22, 1946). This station was about 40 miles upstream from the uppermost area worked in 1944. It was located in the middle section of Pool No. 19, 9 to 15 miles below Lock and Dam No. 18 and 2 to 8 miles below the city of Burlington.

The river stage at the time test netting was begun was lower than in the previous week and it continued to fall during the sampling period here. However, the water level was still quite high, and much of the netting was done in backwater lakes and sloughs that are normally dry later in the season. Netting operations were confined largely to an area just above the mouth of Skunk River in the vicinity of Sullivan Slough and the lower end of Burlington Island. The bottom here was mud, and the water, which had little or no current, varied in depth from 3.5 to 6.0 feet. Some sets were made in the river channel. Trammel netting was carried on by drifting the net in the channel downstream. This type of fishing was conducted at stations having clean sand bottoms and water with current and with depths of 5 to 15 feet.

21.—Oquawka, Illinois (D-MR section, April 24–May 5, 1946). The river between Oquawka and Keithsburg, a distance of 12 miles, was dotted with many islands and sloughs. The west side of the river here was

backed by an extensive levee system forming several drainage districts. The sloughs and backwaters on the Illinois side created good habitat for fish, particularly the sport species. This area was quite similar to the Grafton station described earlier. Above Keithsburg and below Oquawka both sides of the river were backed by levees. According to a local commercial fisherman the current in the river here had been greatly reduced since the installation of Lock and Dam No. 18. Nets were set several miles above Oquawka, in a chute formed by Benton Island, and also below Oquawka, in a chute formed by Island No. 369.

Beginning on September 8, 1947, two poison censuses of fish inhabiting two of the backwaters of this station were made. The backwaters poisoned were sloughs of 1.07 and 1.76 acres.

22.—New Boston, Illinois (D-MR section, May 7–18, 1946). This station was located in the upper section of Pool No. 18, just above New Boston. The mouth of the Iowa River is directly across the Mississippi River from New Boston. On the Iowa side of the Mississippi, netting was done in the chutes above and below the mouth of the Iowa River. Here the current was strong, the water varied in depth from 5 to 10 feet, and the bottom was of mud. On the Illinois side nets were set in the impounded backwaters in the Boston Bay area. A fairly swift current existed here from the discharge of the pumping station of the Bay Island Drainage and Levee District.

23.—Muscatine, Iowa (D-MR section, May 19–30, 1946). This station, located several miles below Muscatine, extended from the mouth of Copperas Creek Diversion channel to Bogus Island. The upper area in the chute by Blanchard Island had been highly recommended by local fishermen for fishing; however, netting here was unsatisfactory. Nets were set at various locations in the steamboat channel in the Blanchard Island locality. The channel sets were made in water of 15-foot depth over sand bottom. There are extensive drainage districts on both sides of the river here, largely confining the river to its channel; however, in the area of Bogus Island on the Iowa side there are some stretches of backwater.

The mussel fishery of the Mississippi River is not within the scope of this paper;

however, it is of interest in relation to fish habitat to mention that no activity in the shell or mussel fishery was observed below the Muscatine area. At Muscatine, on days when favorable weather prevailed, there were usually 12 to 15 shell-fishing boats in view from the Muscatine waterfront. Some activity of shell fishermen was noted upstream as far as Clinton, Iowa. In this stretch of water there is some clean gravel bottom, which apparently furnishes a more suitable habitat for mussels of economic importance than does the lower section of the river visited during the fishery investigation.

24.—Fairport, Iowa (D-MR section, June 2–13, 1946). This station and the one at Bellevue were the only sampling sites in the lower reaches of the pools. As discussed earlier the lower part of a navigation pool differs from the upper by having slower current and a more extensive silt bottom. The netting at the Fairport station was done in the region of Hershey Slough and Wyoming Slough near the mouth of Sweetheart Creek. This site was 2 to 3 miles above Lock and Dam No. 16 and 3 miles below Fairport. The nets were set in water ranging from 3 to 15 feet in depth.

25.—Andalusia, Illinois (D-MR section, April 1–7, June 18–26, and September 15–24, 1946). The Andalusia area, in the middle part of Pool No. 16, was used as the key station in 1946. This station was centrally located in relation to the other stations, and the habitats of the Andalusia area were more like those of the other 1946 stations than the Grafton habitats were like the habitats of the other 1944 stations. The general conditions at Andalusia were typical of those of the canalized section of the river.

River stages at Andalusia were high during April and June as compared with those during September. Netting during the three periods was done in the river channel, sloughs, and chutes near islands numbered 317, 318, and 319. The bottom in the sloughs and chutes was mud and the channel bottom was sand and sand-mud. The bottom of the channel and the current were satisfactory for trammel-net-float fishing. The sloughs here were confined to the Illinois side and the channel followed the Iowa side.

26.—Pleasant Valley, Iowa (D-MR section, June 28–July 9, 1946). This station, located in the upper part of Pool No. 15, was

immediately below Pleasant Valley and 1 to 2 miles below Lock and Dam No. 14. Netting was done in the channel and chutes adjacent to Spencer Island and Campbell Island. The current in the channel was rather strong and the bottom was sand. In the chutes the bottom was of mud and some sand, and the depth of water there varied from 3.5 to 12.0 feet.

Above Lock and Dam No. 14 is the location of the former Le Claire Rapids. The site of these once great rapids is now merely a part of Pool No. 14. The elimination of the Le Claire and Keokuk rapids has greatly improved navigation on the river; however, its effect on spawning grounds for such fish as the blue sucker is not measurable.

27.—Cordova, Illinois (D-MR section, July 11–22, 1946). This station, in the middle reach of Pool No. 14, was located one-half mile to 2 miles above Cordova and 3 miles below the mouth of one of the noted smallmouth bass streams in Iowa, the Wapsipinicon River. Here the Mississippi channel hugged the Illinois shore. On the Iowa side were many bays and sloughs formed by the impoundment. These were dotted with dead trees killed by high water, 2 to 6 feet deep there, with no current; the bottoms were of mud. Netting operations were carried on in an area back as far as 1 mile from the river channel and also in the river channel and sloughs above the mouth of Pinneo Creek.

28.—Fulton, Illinois (D-MR section, July 24–August 4, 1946). The netting at this station was carried on above Fulton and Clinton, on opposite banks of the Mississippi, and was confined within the upper 1.5 miles of Pool No. 14. The current in the channel was swift; the bottom was principally sand but with some rock. The backwater areas were numerous and they were rather shallow, varying in depth from 3 to 4 feet. Sampling was done in the backwaters, the channel, and its adjoining sloughs and chutes.

29.—Sabula, Iowa (D-MR section, August 6–17, 1946). The Sabula station was located in the middle reach of Pool No. 13. The river here was too sluggish to float a trammel net efficiently. The bottom in the channel was mud and sand. Much of the netting at this station was done in the backwaters, a levee borrow pit, and chutes. Stumps, both submerged and protruding,

were numerous in the backwaters. Netting was done also in Savanna Slough. A period of netting was conducted near Savanna, above Sabula, in a levee borrow pit adjacent to the river. Water in this pit was about 4 feet in depth and the bottom was mud. Width of the water area varied from 50 to 75 feet. Following the netting period in this borrow pit a census was made of the fish population, August 13-17, by blocking off the outlet to the river with a seine and introducing a fish poison. The area covered in the poison census was 2.16 acres. Near this location, part of another levee borrow pit was treated with poison. This part was the blind end of the pit, 100 or more feet in width, and 0.964 acre in area. Fish had access to the river from this pit.

30.—Bellevue, Iowa (D-MR section, August 19-30, 1946). This station was located in the lower part of Pool No. 12. As at other stations in the lower parts of navigation pools, the current here was sluggish and the bottom predominantly silt or mud. Netting in the channel was done in the vicinity of islands numbered 242 and 243, 3 to 4 miles above Bellevue and Lock and Dam No. 12. Some nets were set in the channel in water as deep as 15 feet.

In the lower part of this pool, aquatic vegetation was quite abundant. Much of the shore line of the islands was covered with heavy growths of arrowhead, *Sagittaria* sp. Some of the backwater areas had 1- to 2-acre beds of American lotus, *Ne-*

lumbo lutea (Willd.) Pers. The numerous shallow sloughs and small lakes in the area were covered with abundant growths of rice cutgrass, *Leersia oryzoides* (L.) Sw. Some netting was done in the backwaters near the mouth of Small Pox Creek.

31.—Dubuque, Iowa (D-MR section, September 1-12, 1946). This was the uppermost station in that part of the Mississippi River studied in the Caruthersville-Dubuque survey. It was at the northern boundary of the state of Illinois. The river above this station up to Prescott, Wisconsin, was investigated by the states bordering the upper section of the upper Mississippi River, namely, Iowa, Minnesota, and Wisconsin.

The Dubuque station was in the upper part of Pool No. 12, fig. 5, located 1 to 4 miles below the city of Dubuque. Netting was done in the backwaters adjoining Lake Frenress, in chutes, and in channels in the area. The netting sites in backwaters and lakes were in shallow water ranging from 3.5 to 5.0 feet in depth and having mud bottoms. The chutes sampled had sand and mud bottoms, and the channel had a sand bottom. The current in the channel was only moderately swift. Above the sampling area to Lock and Dam No. 11 the river is rather closely confined. The bluffs on both sides of the river in this region are quite high and steep. This section of Illinois and Iowa is referred to by geologists as unglaciated or driftless area.

Appendix B, Table 1.—Number, weight, and per cent of total weight by station of various River survey in 1944 between Caruthers.

SPECIES	CARUTHERSVILLE, MO. APRIL 6-12, 1944			TIPTONVILLE, TENN. APRIL 15-MAY 10, 1944		
	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight
COMMERCIAL FISHES						
<i>Scaphirhynchus albus</i> *.....	0	—	—	0	—	—
Shovelnose sturgeon.....	0	—	—	0	—	—
Paddlefish.....	0	—	—	7	2.65	0.51
American eel.....	0	—	—	0	—	—
Blue sucker.....	0	—	—	0	—	—
Bigmouth buffalo.....	2	1.68	0.53	27	30.62	5.85
Black buffalo.....	0	—	—	7	2.58	0.49
Smallmouth buffalo.....	6	2.90	0.91	23	32.24	6.16
Carp suckers†.....	6	3.86	1.21	28	25.63	4.89
Northern redhorse.....	0	—	—	0	—	—
Carp.....	37	60.10	18.91	63	127.65	24.38
Channel catfish.....	5	1.68	0.53	81	23.30	4.45
Blue catfish.....	16	4.19	1.32	92	39.83	7.61
Yellow bullhead.....	0	—	—	3	2.50	0.48
Brown bullhead.....	0	—	—	1	0.54	0.10
Black bullhead.....	48	21.42	6.74	94	72.30	13.81
Flathead catfish.....	14	14.74	4.64	5	12.93	2.47
Freshwater drum.....	8	1.78	0.56	24	16.11	3.08
Subtotal.....	142	112.35	35.35	455	388.88	74.28
SPORT FISHES						
Grass pickerel.....	0	—	—	0	—	—
Yellow pikeperch.....	0	—	—	0	—	—
Sauger.....	1	0.58	0.18	3	2.21	0.42
Spotted black bass.....	2	1.21	0.38	0	—	—
Largemouth black bass.....	4	2.91	0.92	1	1.51	0.29
Green sunfish.....	0	—	—	17	1.98	0.38
Bluegill.....	8	1.40	0.44	9	1.54	0.29
Warmouth.....	4	0.89	0.28	10	2.90	0.55
Flier.....	0	—	—	0	—	—
White crappie.....	63	17.41	5.48	23	6.97	1.33
Black crappie.....	57	8.87	2.79	16	3.99	0.76
White bass.....	6	2.66	0.84	2	0.25	0.05
Yellow bass.....	1	0.16	0.05	1	0.32	0.06
Subtotal.....	146	36.09	11.36	82	21.67	4.13
PREDATORY FISHES						
Longnose gar.....	1	0.20	0.06	14	60.99	11.65
Shortnose gar.....	69	124.09	39.05	17	28.47	5.43
Alligator gar.....	0	—	—	0	—	—
Bowfin.....	0	—	—	0	—	—
Subtotal.....	70	124.29	39.11	31	89.46	17.08
FORAGE FISHES						
Mooneye and goldeye.....	4	1.37	0.43	5	1.51	0.29
Skipjack.....	3	1.59	0.50	3	1.19	0.23
Gizzard shad.....	93	42.12	13.25	68	20.89	3.99
Golden shiner.....	0	—	—	0	—	—
Subtotal.....	100	45.08	14.18	76	23.59	4.51
Total.....	458	317.81	100.00	644	523.60	100.00

* None taken in test nets but one procured from angler at time of survey.

† *Carpoides* spp.

species of fish (except those in minnow seine collections) taken during the Mississippi
ville, Missouri, and Warsaw, Illinois.

CAIRO, ILL. MAY 18-24, 1944			CAPE GIRARDEAU, MO. MAY 26-31, 1944			GRAND TOWER, ILL. JUNE 2-9, 1944			CHESTER, ILL. JUNE 11-15, 1944		
Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight
0	—	—	0	—	—	0	—	—	0	—	—
0	—	—	0	—	—	0	—	—	0	—	—
14	17.89	2.34	0	—	—	1	1.10	0.12	2	2.98	0.51
4	5.45	0.71	0	—	—	0	—	—	0	—	—
0	—	—	0	—	—	0	—	—	0	—	—
8	34.08	4.47	2	10.57	1.40	5	18.57	2.00	1	3.17	0.54
1	1.87	0.25	7	60.76	8.07	7	34.39	3.70	0	—	—
22	38.20	5.01	0	—	—	14	31.55	3.39	2	0.48	0.08
40	53.18	6.97	7	13.22	1.76	77	123.18	13.23	7	4.07	0.69
0	—	—	0	—	—	0	—	—	0	—	—
60	132.72	17.39	82	247.08	32.81	162	299.65	32.20	140	271.74	46.43
12	10.18	1.33	4	6.92	0.92	6	6.51	0.70	2	2.32	0.40
20	11.18	1.47	20	19.31	2.56	26	11.11	1.19	10	19.66	3.36
1	1.02	0.13	0	—	—	0	—	—	0	—	—
0	—	—	0	—	—	0	—	—	0	—	—
81	69.42	9.10	2	1.80	0.24	32	18.40	1.98	2	1.26	0.22
33	59.00	7.73	88	327.67	43.50	26	65.46	7.03	88	186.06	31.79
114	46.68	6.12	17	17.55	2.33	30	23.68	2.54	10	7.32	1.25
410	480.87	63.02	229	704.88	93.59	386	633.60	68.08	264	499.06	85.27
0	—	—	0	—	—	0	—	—	0	—	—
0	—	—	0	—	—	0	—	—	0	—	—
8	5.16	0.68	0	—	—	5	3.14	0.34	2	1.60	0.27
0	—	—	0	—	—	0	—	—	0	—	—
0	—	—	0	—	—	2	1.23	0.13	2	0.95	0.16
0	—	—	0	—	—	0	—	—	0	—	—
1	0.35	0.05	0	—	—	10	2.23	0.24	3	0.65	0.11
0	—	—	0	—	—	1	0.22	0.02	0	—	—
1	0.10	0.01	0	—	—	0	—	—	0	—	—
7	1.86	0.24	0	—	—	9	2.70	0.29	4	1.09	0.19
5	1.49	0.20	0	—	—	6	1.59	0.17	7	2.29	0.39
12	5.34	0.70	0	—	—	0	—	—	1	0.40	0.07
0	—	—	0	—	—	0	—	—	0	—	—
34	14.30	1.88	0	—	—	33	11.11	1.19	19	6.98	1.19
5	10.32	1.35	3	10.56	1.40	8	12.08	1.30	3	7.55	1.29
33	31.38	4.11	60	35.02	4.65	268	147.39	15.84	62	59.76	10.21
80	182.29	23.89	1	1.66	0.22	2	58.86	6.32	1	2.38	0.41
1	1.65	0.22	1	1.05	0.14	23	53.49	5.75	2	7.17	1.22
119	225.64	29.57	65	48.29	6.41	301	271.82	29.21	68	76.86	13.13
6	2.72	0.36	0	—	—	4	1.26	0.14	2	0.76	0.13
5	3.16	0.41	0	—	—	0	—	—	0	—	—
71	36.34	4.76	0	—	—	17	12.88	1.38	4	1.64	0.28
0	—	—	0	—	—	0	—	—	0	—	—
82	42.22	5.53	0	—	—	21	14.14	1.52	6	2.40	0.41
645	763.03	100.00	294	753.17	100.00	741	930.67	100.00	357	585.30	100.00

Appendix B, Table 1.—

SPECIES	STE. GENEVIEVE, MO. JUNE 18-24, 1944			CRYSTAL CITY, MO. JUNE 25-30, 1944		
	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight
COMMERCIAL FISHES						
<i>Scaphirhynchus albus</i> *	0	—	—	0	—	—
Shovelnose sturgeon	0	—	—	0	—	—
Paddlefish	0	—	—	0	—	—
American eel	0	—	—	3	7.95	1.01
Blue sucker	0	—	—	0	—	—
Bigmouth buffalo	0	—	—	0	—	—
Black buffalo	1	5.94	0.56	0	—	—
Smallmouth buffalo	14	29.98	2.81	21	14.52	1.84
Carp sucker†	89	148.91	13.97	41	43.44	5.50
Northern redhorse	0	—	—	7	4.20	0.53
Carp	320	616.70	57.87	210	494.07	62.60
Channel catfish	27	49.96	4.69	6	11.62	1.47
Blue catfish	8	3.72	0.35	14	13.48	1.71
Yellow bullhead	0	—	—	0	—	—
Brown bullhead	0	—	—	0	—	—
Black bullhead	0	—	—	3	1.53	0.19
Flathead catfish	28	106.11	9.96	38	106.81	13.53
Freshwater drum	45	39.00	3.66	34	26.79	3.40
Subtotal	532	1,000.32	93.87	377	724.41	91.78
SPORT FISHES						
Grass pickerel	0	—	—	0	—	—
Yellow pikeperch	0	—	—	0	—	—
Sauger	2	1.66	0.16	0	—	—
Spotted black bass	0	—	—	0	—	—
Largemouth black bass	0	—	—	1	0.77	0.10
Green sunfish	0	—	—	1	0.32	0.04
Bluegill	0	—	—	4	0.73	0.09
Warmouth	0	—	—	0	—	—
Flier	0	—	—	0	—	—
White crappie	0	—	—	10	2.57	0.33
Black crappie	0	—	—	28	9.13	1.16
White bass	0	—	—	3	1.59	0.20
Yellow bass	0	—	—	0	—	—
Subtotal	2	1.66	0.16	47	15.11	1.92
PREDATORY FISHES						
Longnose gar	7	19.65	1.84	6	20.79	2.63
Shortnose gar	49	42.03	3.94	20	17.07	2.16
Alligator gar	0	—	—	0	—	—
Bowfin	0	—	—	0	—	—
Subtotal	56	61.68	5.78	26	37.86	4.79
FORAGE FISHES						
Mooneye and goldeye	2	1.22	0.11	20	8.93	1.13
Skipjack	0	—	—	0	—	—
Gizzard shad	2	0.84	0.08	9	3.00	0.38
Golden shiner	0	—	—	0	—	—
Subtotal	4	2.06	0.19	29	11.93	1.51
Total	594	1,065.72	100.00	479	789.31	100.00

* None taken in test nets but one procured from angler at time of survey.

† *Carpinoides* spp.

Continued.

CLIFF CAVE, MO.
JULY 2-8, 1944BELOW MOUTH OF
MISSOURI RIVER
JULY 10-15, 1944ABOVE MOUTH OF
MISSOURI RIVER
JULY 10-15, 1944GRAFTON, ILL.
MARCH 22-30, 1944

Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight
0	—	—	0	—	—	1	0.12	0.01	0	—	—
0	—	—	0	—	—	0	—	—	0	—	—
0	—	—	0	—	—	0	—	—	1	0.85	0.11
3	6.50	0.81	0	—	—	3	7.40	0.87	0	—	—
0	—	—	0	—	—	0	—	—	0	—	—
3	10.42	1.29	0	—	—	7	19.58	2.30	13	19.13	2.57
7	20.27	2.51	0	—	—	0	—	—	9	31.55	4.23
25	79.38	9.82	0	—	—	6	2.19	0.26	21	13.29	1.78
33	52.57	6.50	6	10.32	3.70	17	16.35	1.92	20	12.44	1.67
0	—	—	0	—	—	0	—	—	0	—	—
183	470.87	58.25	54	133.79	48.00	309	372.35	43.83	51	88.08	11.81
4	5.44	0.67	1	2.40	0.86	23	28.75	3.39	22	4.09	0.55
19	12.85	1.59	6	0.52	0.19	14	5.23	0.62	8	5.96	0.80
0	—	—	0	—	—	0	—	—	1	0.50	0.07
0	—	—	0	—	—	0	—	—	2	0.69	0.09
0	—	—	0	—	—	0	—	—	25	14.49	1.94
25	88.91	11.00	27	101.75	36.50	44	81.92	9.64	0	—	—
41	30.82	3.81	25	14.23	5.11	227	81.33	9.58	73	17.55	2.35
343	778.03	96.25	119	263.01	94.36	651	615.22	72.42	246	208.62	27.97
0	—	—	0	—	—	0	—	—	2	1.05	0.14
0	—	—	0	—	—	0	—	—	0	—	—
0	—	—	0	—	—	1	1.04	0.12	0	—	—
0	—	—	0	—	—	0	—	—	0	—	—
0	—	—	0	—	—	11	16.66	1.96	30	47.20	6.33
0	—	—	0	—	—	0	—	—	0	—	—
0	—	—	4	0.64	0.23	31	8.72	1.03	288	65.79	8.82
0	—	—	0	—	—	0	—	—	36	10.81	1.45
0	—	—	0	—	—	0	—	—	0	—	—
0	—	—	3	1.01	0.36	4	1.14	0.13	74	35.23	4.72
0	—	—	4	1.87	0.67	303	116.27	13.69	331	146.17	19.60
0	—	—	0	—	—	1	0.56	0.07	3	1.69	0.23
0	—	—	0	—	—	0	—	—	1	0.38	0.05
0	—	—	11	3.52	1.26	351	144.39	17.00	765	308.32	41.34
4	9.64	1.19	0	—	—	7	7.34	0.87	5	12.23	1.64
21	20.72	2.56	3	2.76	0.99	100	71.45	8.41	76	90.09	12.08
0	—	—	0	—	—	0	—	—	0	—	—
0	—	—	2	9.46	3.39	2	3.94	0.46	8	28.18	3.78
25	30.36	3.75	5	12.22	4.38	109	82.73	9.74	89	130.50	17.50
0	—	—	0	—	—	6	3.70	0.44	7	1.86	0.25
0	—	—	0	—	—	0	—	—	0	—	—
0	—	—	0	—	—	5	3.42	0.40	134	95.81	12.85
0	—	—	0	—	—	0	—	—	2	0.67	0.09
0	—	—	0	—	—	11	7.12	0.84	143	98.34	13.19
368	808.39	100.00	135	278.75	100.00	1,122	849.46	100.00	1,243	745.78	100.00

Appendix B, Table 1.—

SPECIES	GRAFTON, ILL. JULY 17-25, 1944			GRAFTON, ILL. SEPT. 22-27, 1944		
	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight
COMMERCIAL FISHES						
<i>Scaphirhynchus albus</i> *.....	0	—	—	0	—	—
Shovelnose sturgeon.....	0	—	—	0	—	—
Paddlefish.....	0	—	—	0	—	—
American eel.....	3	7.28	1.15	5	11.51	3.41
Blue sucker.....	0	—	—	0	—	—
Bigmouth buffalo.....	12	19.11	3.02	0	—	—
Black buffalo.....	4	28.04	4.43	1	2.80	0.83
Smallmouth buffalo.....	39	18.24	2.88	22	15.21	4.51
Carp suckers†.....	35	26.74	4.23	14	10.43	3.09
Northern redhorse.....	0	—	—	3	3.84	1.14
Carp.....	46	82.21	12.99	18	41.00	12.15
Channel catfish.....	5	7.42	1.17	11	4.02	1.19
Blue catfish.....	2	0.27	0.04	2	1.33	0.39
Yellow bullhead.....	6	2.93	0.46	13	7.71	2.28
Brown bullhead.....	3	3.45	0.55	0	—	—
Black bullhead.....	14	7.64	1.21	0	—	—
Flathead catfish.....	14	23.46	3.71	6	12.56	3.72
Freshwater drum.....	33	16.13	2.55	25	11.28	3.34
Subtotal.....	216	242.92	38.39	120	121.69	36.05
SPORT FISHES						
Grass pickerel.....	0	—	—	0	—	—
Yellow pikeperch.....	0	—	—	0	—	—
Sauger.....	1	1.36	0.21	2	2.56	0.76
Spotted black bass.....	0	—	—	0	—	—
Largemouth black bass.....	36	34.03	5.38	28	25.83	7.65
Green sunfish.....	0	—	—	0	—	—
Bluegill.....	132	30.81	4.87	17	3.20	0.95
Warmouth.....	13	3.89	0.62	3	1.00	0.30
Flier.....	0	—	—	0	—	—
White crappie.....	74	16.84	2.66	58	16.00	4.74
Black crappie.....	353	113.73	17.97	185	80.13	23.74
White bass.....	32	16.71	2.64	30	16.93	5.02
Yellow bass.....	1	0.45	0.07	1	0.23	0.07
Subtotal.....	642	217.82	34.42	324	145.88	43.23
PREDATORY FISHES						
Longnose gar.....	13	30.42	4.81	1	2.68	0.79
Shortnose gar.....	43	43.92	6.94	4	4.30	1.27
Alligator gar.....	1	4.10	0.65	0	—	—
Bowfin.....	12	29.00	4.58	8	29.11	8.62
Subtotal.....	69	107.44	16.98	13	36.09	10.68
FORAGE FISHES						
Mooneye and goldeye.....	6	6.14	0.97	3	2.91	0.86
Skipjack.....	0	—	—	0	—	—
Gizzard shad.....	101	58.45	9.24	94	30.99	9.18
Golden shiner.....	0	—	—	0	—	—
Subtotal.....	107	64.59	10.21	97	33.90	10.04
Total.....	1,034	632.77	100.00	554	337.56	100.00

* None taken in test nets but one procured from angler at time of survey.

† *Carpiodes* spp.

Continued.

WINFIELD, MO. JULY 27-AUG. 2, 1944			HAMBURG, ILL. AUG. 3-9, 1944			LOUISIANA, MO. AUG. 12-17, 1944			CINCINNATI LANDING, ILL. AUG. 19-23, 1944		
Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight
0	—	—	0	—	—	0	—	—	0	—	—
0	—	—	0	—	—	0	—	—	0	—	—
7	4.96	0.57	1	0.22	0.04	0	—	—	0	—	—
0	—	—	2	5.37	1.01	0	—	—	3	4.98	1.43
0	—	—	0	—	—	0	—	—	1	2.80	0.80
7	17.60	2.03	2	5.29	0.99	3	6.64	1.99	5	10.23	2.94
3	8.79	1.01	3	10.74	2.01	1	2.26	0.68	2	3.34	0.96
57	47.72	5.51	24	28.26	5.29	23	15.81	4.73	30	21.42	6.15
11	8.04	0.93	36	34.29	6.42	22	18.36	5.49	8	7.64	2.19
0	—	—	1	1.85	0.35	0	—	—	3	6.02	1.73
79	118.76	13.71	55	98.56	18.45	33	75.25	22.50	45	104.04	29.88
24	27.36	3.16	34	33.89	6.35	18	20.81	6.22	13	9.39	2.70
24	16.23	1.87	3	2.48	0.46	9	1.64	0.49	8	3.62	1.04
1	0.16	0.02	2	2.06	0.39	0	—	—	0	—	—
0	—	—	0	—	—	0	—	—	0	—	—
5	3.72	0.43	0	—	—	0	—	—	0	—	—
39	67.16	7.75	15	40.17	7.52	19	36.39	10.88	33	106.49	30.58
79	48.69	5.62	34	28.37	5.31	98	61.67	18.44	52	32.77	9.41
336	369.19	42.61	212	291.55	54.59	226	238.83	71.42	203	312.74	89.81
0	—	—	0	—	—	0	—	—	0	—	—
1	1.43	0.17	0	—	—	0	—	—	0	—	—
2	1.64	0.19	0	—	—	3	3.38	1.01	7	6.59	1.89
0	—	—	0	—	—	0	—	—	0	—	—
10	10.23	1.18	5	5.53	1.03	0	—	—	0	—	—
0	—	—	0	—	—	0	—	—	0	—	—
28	5.76	0.66	42	9.40	1.76	0	—	—	0	—	—
0	—	—	0	—	—	0	—	—	0	—	—
0	—	—	0	—	—	0	—	—	0	—	—
254	62.21	7.18	236	61.79	11.57	19	7.40	2.21	1	0.45	0.13
70	20.52	2.37	77	25.84	4.84	11	3.80	1.14	6	2.01	0.58
23	16.50	1.90	26	12.89	2.41	0	—	—	3	6.91	1.98
1	0.34	0.04	0	—	—	0	—	—	0	—	—
389	118.63	13.69	386	115.45	21.61	33	14.58	4.36	17	15.96	4.58
18	50.47	5.83	4	8.91	1.67	9	28.65	8.57	2	3.34	0.96
136	121.50	14.02	71	60.04	11.24	22	24.13	7.22	6	8.42	2.42
0	—	—	0	—	—	0	—	—	0	—	—
41	128.05	14.78	7	25.42	4.76	2	5.43	1.62	0	—	—
195	300.02	34.63	82	94.37	17.67	33	58.21	17.41	8	11.70	3.38
5	2.17	0.25	1	0.17	0.03	1	0.55	0.16	0	—	—
0	—	—	0	—	—	0	—	—	0	—	—
142	76.43	8.82	67	32.57	6.10	44	22.23	6.65	18	7.78	2.23
0	—	—	0	—	—	0	—	—	0	—	—
147	78.60	9.07	68	32.74	6.13	45	22.78	6.81	18	7.78	2.23
1,067	866.44	100.00	748	534.11	100.00	337	334.40	100.00	246	348.24	100.00

Appendix B, Table 1.—

SPECIES	HANNIBAL, MO. AUG. 25-30, 1944			QUINCY, ILL. SEPT. 2-6, 1944		
	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight
COMMERCIAL FISHES						
<i>Scaphirhynchus albus</i> *.....	0	—	—	0	—	—
Shovelnose sturgeon.....	0	—	—	3	4.78	0.40
Paddlefish.....	0	—	—	25	104.70	8.69
American eel.....	6	14.26	3.18	2	3.25	0.27
Blue sucker.....	0	—	—	0	—	—
Bigmouth buffalo.....	2	6.85	1.53	6	12.24	1.01
Black buffalo.....	2	3.25	0.72	2	3.72	0.31
Smallmouth buffalo.....	6	15.98	3.57	31	26.26	2.18
Carp suckers†.....	30	25.52	5.70	120	105.46	8.75
Northern redhorse.....	1	1.27	0.28	11	1.18	0.10
Carp.....	75	178.52	39.84	137	345.79	28.70
Channel catfish.....	18	9.73	2.17	126	67.74	5.62
Blue catfish.....	1	0.31	0.07	7	1.53	0.13
Yellow bullhead.....	0	—	—	0	—	—
Brown bullhead.....	0	—	—	0	—	—
Black bullhead.....	0	—	—	2	1.97	0.16
Flathead catfish.....	21	88.97	19.86	24	83.51	6.93
Freshwater drum.....	45	36.54	8.15	36	25.33	2.10
Subtotal.....	207	381.20	85.07	522	787.46	65.35
SPORT FISHES						
Grass pickerel.....	0	—	—	0	—	—
Yellow pikeperch.....	0	—	—	1	4.00	0.33
Sauger.....	4	4.69	1.05	4	5.59	0.46
Spotted black bass.....	0	—	—	0	—	—
Largemouth black bass.....	0	—	—	0	—	—
Green sunfish.....	0	—	—	0	—	—
Bluegill.....	0	—	—	6	1.02	0.08
Warmouth.....	0	—	—	0	—	—
Flier.....	0	—	—	0	—	—
White crappie.....	41	7.88	1.76	61	27.19	2.26
Black crappie.....	11	3.56	0.79	26	12.02	1.00
White bass.....	2	0.80	0.18	11	6.72	0.56
Yellow bass.....	0	—	—	0	—	—
Subtotal.....	58	16.93	3.78	109	56.54	4.69
PREDATORY FISHES						
Longnose gar.....	4	8.73	1.95	38	65.81	5.46
Shortnose gar.....	25	28.14	6.28	209	249.16	20.68
Alligator gar.....	0	—	—	0	—	—
Bowfin.....	0	—	—	1	2.71	0.22
Subtotal.....	29	36.87	8.23	248	317.68	26.36
FORAGE FISHES						
Mooneye and goldeye.....	9	4.48	1.00	6	3.27	0.27
Skipjack.....	0	—	—	0	—	—
Gizzard shad.....	28	8.61	1.92	97	40.06	3.33
Golden shiner.....	0	—	—	0	—	—
Subtotal.....	37	13.09	2.92	103	43.33	3.60
Total.....	331	448.09	100.00	982	1,205.01	100.00

* None taken in test nets but one procured from angler at time of survey.

† *Carpiodes* spp.‡ Undetermined species of redhorse (*Moxostoma*).

Concluded.

CANTON, Mo. SEPT. 8-13, 1944			WARSAW, ILL. SEPT. 14-19, 1944			TOTAL NUMBER OF FISH CAUGHT	TOTAL WEIGHT IN POUNDS	PER CENT OF TOTAL WEIGHT
Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight			
0	—	—	0	—	—	1	0.12	0.00
0	—	—	0	—	—	3	4.78	0.03
18	29.92	5.71	0	—	—	76	165.27	1.14
2	3.62	0.69	1	2.67	0.32	37	80.24	0.55
2	3.70	0.71	0	—	—	3	6.50	0.05
1	3.03	0.56	3	6.04	0.72	109	234.85	1.62
0	—	—	1	5.37	0.64	58	225.67	1.56
23	30.25	5.77	59	124.05	14.86	468	587.93	4.06
81	78.97	15.06	211	219.46	26.29	939	1,042.08	7.20
1	1.84	0.35	3	4.69	0.56	20	24.89	0.17
52	139.11	26.54	114	254.47	30.48	2,325	4,752.51	32.83
10	8.73	1.67	16	10.21	1.22	468	352.47	2.43
1	0.19	0.04	1	3.68	0.44	311	178.32	1.23
1	0.44	0.08	0	—	—	28	17.32	0.12
0	—	—	0	—	—	6	4.68	0.03
1	1.45	0.28	1	0.46	0.06	310	215.86	1.49
19	38.57	7.36	11	60.61	7.26	617	1,709.25	11.81
30	24.12	4.60	36	32.80	3.93	1,116	640.54	4.43
242	363.94	69.42	457	724.51	86.78	6,895	10,243.28	70.75
0	—	—	0	—	—	2	1.05	0.01
0	—	—	0	—	—	2	5.43	0.04
0	—	—	22	21.35	2.56	67	62.55	0.43
0	—	—	0	—	—	2	1.21	0.01
2	1.32	0.25	1	1.08	0.13	133	149.25	1.03
0	—	—	0	—	—	18	2.30	0.02
12	2.21	0.42	0	—	—	595	134.45	0.93
0	—	—	0	—	—	67	19.71	0.14
0	—	—	0	—	—	1	0.10	0.00
53	25.91	4.94	4	1.90	0.23	998	297.55	2.06
16	10.20	1.95	3	1.42	0.17	1,515	564.90	3.90
56	15.85	3.02	6	3.93	0.47	217	109.73	0.76
0	—	—	0	—	—	6	1.88	0.01
139	55.49	10.58	36	29.68	3.56	3,623	1,350.11	9.34
26	14.27	2.72	16	18.70	2.24	194	403.33	2.79
76	57.39	10.95	41	39.94	4.78	1,411	1,307.17	9.03
0	—	—	0	—	—	85	249.29	1.72
0	—	—	0	—	—	110	324.66	2.24
102	71.66	13.67	57	58.64	7.02	1,800	2,284.45	15.78
4	1.93	0.37	18	9.69	1.16	109	54.64	0.38
1	1.09	0.21	3	2.12	0.25	15	9.15	0.06
54	30.12	5.75	21	10.28	1.23	1,069	534.46	3.69
0	—	—	0	—	—	2	0.67	0.00
59	33.14	6.33	42	22.09	2.64	1,195	598.92	4.13
542	524.23	100.00	592	834.92	100.00	13,513	14,476.76	100.00

Appendix B, Table 2.—Number, weight, and per cent of total weight by station of various species of fish (except those in minnow seine collections) taken during the Mississippi River survey in 1946 between Burlington and Dubuque, Iowa.

SPECIES	BURLINGTON, IOWA APRIL 10-22, 1946			OQUAWKA, ILL. APRIL 24-MAY 5, 1946			NEW BOSTON, ILL. MAY 7-18, 1946			MUSCATINE, IOWA MAY 19-30, 1946			FAIRPORT, IOWA JUNE 2-13, 1946			ANDALUSIA, ILL. APRIL 1-7, 1946		
	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight
COMMERCIAL FISHES																		
Shovelnose sturgeon.....	0	—	—	0	—	—	0	—	—	0	—	—	0	—	—	147	197.10	41.54
Mooneye.....	83	10.41	1.13	3	0.23	0.04	12	1.74	0.15	1	0.18	0.01	1	0.33	0.03	50	10.24	2.16
Goldeye.....	28	10.44	1.13	0	—	—	1	0.34	0.03	0	—	—	5	5.76	0.62	11	8.80	1.85
American eel.....	0	—	—	0	—	—	1	3.25	0.30	2	4.39	0.31	2	3.34	0.36	0	—	—
Blue sucker.....	0	—	—	0	—	—	0	—	—	0	—	—	0	—	—	0	—	—
Bigmouth buffalo.....	87	237.73	25.78	22	59.73	10.86	7	26.50	2.41	11	11.87	0.84	12	37.12	4.00	6	14.09	2.97
Black buffalo.....	3	22.52	2.44	2	6.58	1.20	2	9.42	0.86	0	—	—	0	—	—	1	2.08	0.44
Smallmouth buffalo.....	175	76.90	8.34	42	54.91	9.99	12	11.71	1.07	27	49.27	3.46	19	31.00	3.34	32	63.61	13.41
Carp suckers*.....	139	144.21	15.64	109	142.76	25.96	181	238.05	21.67	211	298.66	21.00	159	247.26	26.62	38	33.99	7.16
White sucker.....	1	0.68	0.07	0	—	—	0	—	—	0	—	—	0	—	—	0	—	—
Spotted sucker.....	0	—	—	0	—	—	1	0.91	0.08	0	—	—	0	—	—	0	—	—
Silver redhorse.....	0	—	—	0	—	—	0	—	—	0	—	—	0	—	—	0	—	—
Northern redbreast.....	0	—	—	1	4.07	0.74	2	3.53	0.32	1	2.20	0.15	5	7.78	0.84	2	1.70	0.36
Carp.....	72	242.32	26.28	33	127.18	23.13	91	324.26	29.52	220	816.55	57.42	83	263.01	28.32	14	50.56	10.66
Channel catfish.....	189	41.33	4.48	14	7.80	1.42	55	16.28	1.48	78	21.23	1.49	103	57.22	6.16	104	25.79	5.43
Yellow bullhead.....	0	—	—	5	1.82	0.33	3	1.72	0.16	1	0.71	0.05	0	—	—	0	—	—
Black bullhead.....	10	1.67	0.18	6	3.50	0.64	5	2.88	0.26	1	0.50	0.04	0	—	—	7	1.75	0.37
Flathead catfish.....	3	1.62	0.18	3	1.11	0.20	8	30.96	2.82	4	4.43	0.31	29	180.52	19.44	1	2.45	0.52
Freshwater drum.....	164	52.51	5.69	13	7.97	1.45	19	5.22	0.48	64	75.24	5.29	15	18.42	1.98	8	10.48	2.21
Subtotal.....	954	842.34	91.34	253	417.66	75.96	400	676.77	61.61	621	1,285.23	90.37	433	851.76	91.71	421	422.64	80.08

SPORT FISHES

[illegible]

* *Carpoides* sp.

Appendix B, Table 2.—Continued.

SPECIES	ANDALUSIA, ILL. JUNE 18-26, 1946			ANDALUSIA, ILL. SEPT. 15-24, 1946			PLEASANT VALLEY, IOWA JUNE 28-JULY 9, 1946			CORDOVA, ILL. JULY 11-22, 1946			FULTON, ILL. JULY 24-AUG. 4, 1946			SABULA, IOWA AUG. 6-17, 1946		
	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight
COMMERCIAL FISHES																		
Shovelnose sturgeon...	56	81.22	5.46	77	82.44	5.01	0	—	—	0	—	—	0	—	—	0	—	—
Mooneye...	4	1.43	0.10	8	1.78	0.11	2	0.35	0.04	9	1.69	0.22	0	0.30	0.02	0	—	—
Goldeye...	2	0.51	0.03	23	3.77	0.23	5	2.96	0.35	6	0.73	0.09	3	0.94	0.07	0	—	—
American eel...	3	8.21	0.55	1	2.68	0.16	1	1.75	0.21	1	3.83	0.46	1	3.00	0.22	1	5.25	0.80
Blue sucker...	0	—	—	3	9.09	0.55	1	3.54	0.41	1	3.58	0.46	0	—	—	0	—	—
Bigmouth buffalo...	45	112.19	7.54	6	18.84	1.15	18	50.07	5.86	7	23.21	2.99	12	15.22	1.09	10	43.14	6.55
Black buffalo...	2	15.05	1.01	2	7.95	0.48	3	10.31	1.21	2	14.11	1.82	3	3.43	0.25	4	14.40	2.19
Smallmouth buffalo...	49	80.27	5.39	33	44.11	2.68	40	66.64	7.80	28	18.64	2.40	11	4.80	0.34	0	—	—
Carp suckers*	291	407.04	27.36	122	144.11	8.76	124	154.55	18.10	36	65.76	8.47	44	45.22	3.25	16	21.70	3.30
White sucker...	0	—	—	0	—	—	3	5.41	0.63	0	—	—	0	—	—	0	—	—
Spotted sucker...	0	—	—	0	—	—	0	—	—	0	—	—	0	—	—	0	—	—
Silver redhorse...	0	—	—	1	2.57	0.16	0	—	—	0	—	—	0	—	—	0	—	—
Northern redhorse...	9	11.51	0.77	15	21.39	1.30	7	7.58	0.89	2	5.30	0.68	1	2.99	0.22	3	6.62	1.00
Carp...	93	336.50	22.61	333	1,115.82	67.83	38	157.03	18.39	79	345.12	44.46	132	467.26	33.56	52	217.81	33.09
Channel catfish...	183	47.84	3.21	45	6.70	0.41	84	32.17	3.77	57	29.70	3.83	74	17.58	1.26	13	4.72	0.72
Yellow bullhead...	1	0.15	0.01	0	—	—	0	—	—	0	—	—	0	—	—	0	—	—
Black bullhead...	16	2.98	0.20	1	0.13	0.01	2	0.76	0.09	1	0.86	0.11	3	0.62	0.04	0	—	—
Flathead catfish...	33	229.10	15.40	17	43.82	2.66	54	231.72	27.14	18	68.25	8.79	23	43.89	3.15	31	92.58	14.07
Freshwater drum...	112	109.48	7.36	86	73.05	4.44	109	77.83	9.11	66	49.87	6.43	181	158.70	11.40	53	51.90	7.89
Subtotal...	899	1,443.48	97.00	773	1,578.25	95.94	491	802.67	94.00	313	630.65	81.24	489	703.95	54.87	183	458.12	69.61

SPORT FISHES											
Pike	0	—	—	—	—	0	—	—	14	35 01	2 51
Yellow pikeperch	4	3 29	0 22	5 51	0 33	0	—	—	1	0 31	0 02
Sauger	19	14 13	0 95	16 57	1 01	1	1 55	0 20	3	2 49	0 18
Spotted black bass	0	—	—	—	—	0	—	—	2	0 93	0 07
Largemouth black bass	0	—	—	—	—	0	—	—	3	3 63	0 26
Green sunfish	0	—	—	0 61	0 04	0	—	—	0	—	—
Bluegill	1	—	—	0 08	—	0	1 76	0 23	69	19 87	1 43
Warmouth	0	—	—	—	0 01	0	—	—	0	—	—
White crappie	10	0 73	0 05	13 12	0 80	186	55 72	7 18	656	205 36	14 75
Black crappie	9	0 54	0 04	4 41	0 27	105	29 00	3 74	493	132 68	9 53
White bass	2	0 26	0 02	3 02	0 18	5	3 27	0 42	9	3 42	0 25
Yellow bass	2	0 99	0 07	8 68	0 53	7	2 50	0 32	0	—	—
<i>Subtotal</i>	46	19 94	1 35	52 00	3 17	308	93 80	12 09	1,250	403.70	29 00
PREDATORY FISHES											
Longnose gar	3	4 70	0 32	3 00	0 18	3	5 33	0 69	1	0 56	0 04
Shortnose gar	10	10 94	0 73	10 59	0 64	30	41 72	5 38	3	2 97	0 21
Bowfin	2	6 55	0 44	—	—	1	3 30	0 42	62	217.67	15 63
<i>Subtotal</i>	15	22 19	1 49	13 59	0 82	34	50 35	6 49	66	221.20	15 88
FORAGE FISHES											
Gizzard shad	2	2 32	0 16	1 20	0 07	4	1 38	0 18	7	3 49	0 25
<i>Total</i>	962	1,487.93	100.00	1,067.04	100.00	650	776	18 100.00	1,812.1	302.31	100.00
										818.658	12 100.00

* *Carpiodes* spp.

Appendix B, Table 2.—Concluded.

SPECIES	BELLEVUE, IOWA AUG. 19-30, 1946			DUBUQUE, IOWA SEPT. 1-12, 1946			TOTAL NUMBER OF FISH CAUGHT	TOTAL WEIGHT IN POUNDS	PER CENT OF TOTAL WEIGHT
	Number	Weight, Pounds	Per Cent of Weight	Number	Weight, Pounds	Per Cent of Weight			
COMMERCIAL FISHES									
Shovelnose sturgeon.....	0	—	—	1	4.22	0.46	281	364.98	2.64
Mooneye.....	0	—	—	0	—	—	174	28.68	0.21
Goldeye.....	0	—	—	0	—	—	84	34.25	0.25
American eel.....	1	2.35	0.34	3	9.10	1.00	17	47.15	0.34
Blue sucker.....	0	—	—	0	—	—	5	16.21	0.12
Bigmouth buffalo.....	26	68.71	9.86	8	38.06	4.18	277	756.48	5.47
Black buffalo.....	2	10.24	1.47	3	11.22	1.23	29	127.31	0.92
Smallmouth buffalo.....	5	10.77	1.55	13	11.01	1.21	486	523.64	3.79
Carp suckers*.....	13	11.31	1.62	8	7.50	0.82	1,491	1,962.12	14.20
White sucker.....	2	3.18	0.46	0	—	—	6	9.27	0.07
Spotted sucker.....	0	—	—	1	1.43	0.16	2	2.34	0.02
Silver redhorse.....	0	—	—	0	—	—	1	2.57	0.02
Northern redhorse.....	47	110.74	15.90	9	21.66	2.38	104	207.07	1.50
Carp.....	42	197.38	28.34	65	322.22	35.35	1,347	4,983.02	36.06
Channel catfish.....	52	30.00	4.31	64	18.24	2.00	1,115	356.60	2.58
Yellow bullhead.....	0	—	—	0	—	—	10	4.40	0.03
Black bullhead.....	49	85.99	12.35	13	3.78	0.41	65	19.43	0.14
Flathead catfish.....	94	63.27	9.08	21	82.31	9.03	294	1,098.75	7.95
Freshwater drum.....	333	593.94	85.28	101	88.11	9.67	1,088	842.05	6.09
Subtotal.....				313	618.86	67.90	6,876	11,386.32	82.40

SPOTT FISHES

Pike.....	0	—	13	33.15	3.64	35	90.92	0.66
Yellow pikeperch.....	1	0.62	3	11.71	1.28	17	24.98	0.18
Sauger.....	3	1.64	6	5.18	0.57	68	53.96	0.39
Spotted black bass.....	0	—	0	—	—	2	0.93	0.01
Largemouth black bass.....	1	1.02	4	4.40	0.48	18	20.72	0.15
Green sunfish.....	0	—	0	—	—	3	0.31	0.00
Bluegill.....	27	2.86	101	21.68	2.38	308	71.31	0.52
Warmouth.....	0	—	1	0.61	0.07	10	3.84	0.03
White crappie.....	175	42.25	217	51.16	5.61	2,677	705.67	5.11
Black crappie.....	77	18.31	183	71.90	7.89	1,452	394.25	2.85
White bass.....	44	17.57	12	4.87	0.53	162	59.00	0.43
Yellow bass.....	1	0.66	0	—	—	258	81.74	0.59
<i>Subtotal</i>	320	84.93	540	204.66	22.45	5,010	1,507.63	10.92

PREDATORY FISHES

Longnose gar.....	1	2.70	8	10.33	1.13	38	93.47	0.68
Shortnose gar.....	5	6.76	17	18.51	2.03	209	246.01	1.78
Bowfin.....	3	7.73	16	46.34	5.08	154	514.15	3.72
<i>Subtotal</i>	9	17.19	41	75.18	8.24	401	853.63	6.18
FORAGE FISHES								
Gizzard shad.....	10	0.41	73	12.83	1.41	237	69.91	0.50
<i>Total</i>	681	696.47	667	911.53	100.00	12,524	13,817.49	100.00

* *Carpioides* spp.

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of the

ILLINOIS NATURAL HISTORY SURVEY

HARLOW B. MILLS, *Chief*

Tularemia, Weather, and Rabbit Populations

RALPH E. YEATTER

DAVID H. THOMPSON



Printed by Authority of the
STATE OF ILLINOIS
ADLAI E. STEVENSON, *Governor*

DEPARTMENT OF REGISTRATION AND EDUCATION
C. HOBART ENGLE, *Director*

STATE OF ILLINOIS

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NATURAL HISTORY SURVEY DIVISION

HARLOW B. MILLS, *Chief*

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June 1952

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*Employed by the Illinois Department of Conservation and assigned to the Natural History Survey for administrative and technical supervision.

†Employed by the Illinois Department of Conservation under terms of the Federal Aid in Wildlife Restoration Act and assigned to the Natural History Survey for administrative and technical supervision.

This paper is a contribution from the Section of Game Research and Management.

FOREWORD

IT IS commonly assumed, by people who are not immediately associated with research, that endeavors in this field of activity can be completed in a short time and that findings of value will always accrue. This assumption is often, but not by any means always, valid. Further, short-term researches almost universally have their base in painstaking studies which have progressed over a long period, some time previous to the initiation of the short-term observations. Values which result from research studies are often so closely intertwined with time that these values do not become significant until observations have been continued over a long period. This is the case in the present important contribution, a study correlating game populations, weather, and human health, and utilizing observations covering about a quarter of a century.

Dr. Thompson was zoologist for the Illinois Natural History Survey from 1923 to 1944 and, since that time, has been Senior Naturalist for the Forest Preserve District of Cook County, Illinois. Because of his earlier training in animal pathology and statistics, he became interested in tularemia

soon after the first cases were reported in Illinois. In 1934 Dr. Yeatter, a specialist in research and management of upland game in the Middle West, joined our staff and teamed up with Dr. Thompson to work on the relation of human tularemia to rabbit hunting in Illinois. Dr. Yeatter has been principally responsible for completing the project during the past 10 years and for preparing this manuscript for publication. These men noticed the relationship between mild autumn temperatures and the severe outbreaks of human tularemia which occurred in Illinois following the opening of the rabbit-hunting seasons in 1938 and 1939. Later they learned that Dr. Robert G. Green of Minnesota had already foreseen this relationship from a consideration of the life history of the ticks which transmit the infection from rabbit to rabbit and from a study of the course of the disease in the cottontail.

The following study should be of interest to a great many people.

HARLOW B. MILLS, *Chief*
Illinois Natural History Survey



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Hunters in an uncultivated gray soil prairie area in southern Illinois. This part of the state, which has a large cottontail population, has a relatively high human tularemia rate.

Tularemia, Weather, and Rabbit Populations

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TULAREMIA, a disease of rabbits and hares (lagomorphs), rodents, and several other animals, is transmissible to man. In the period 1926-1949, Illinois had more than 3,000 reported cases of human tularemia, about twice as many as any of the other states. The great majority of these Illinois cases were traceable to contact with cottontail rabbits, fig. 1.† Because these rabbits are widely distributed on agricultural lands throughout Illinois, and because they are able to maintain themselves under heavy hunting pressure, they rank among the chief game animals of the state. At one time, cottontail rabbits probably made up about two-thirds of the total game bag of Illinois hunters, but, since the tularemia hazard has become generally recognized, rabbit hunting has lost some of its former popularity. Thus, tularemia is of concern to many thousands of people in Illinois not only because of its relation to public health, but also because of its adverse effect on the sport of hunting.

This paper deals with the relation of human tularemia in different parts of the state and in different years to weather, to the abundance of rabbits, and to some other aspects of its epidemiology. In analyzing the information on tularemia in Illinois,

the writers have made an effort to determine the methods of management which would permit Illinois hunters to enjoy the sport of rabbit hunting without undue risk of infection. In a report by the writers (Thompson & Yeatter 1941) at the Seventh Midwest Wildlife Conference, Des Moines, Iowa, December, 1941, and in a Natural History Survey release (Anonymous 1941), the writers stated that the human tularemia rate in Illinois is related to weather at the time of the opening of the hunting season. They added that in years in which the mean date of the first 10 freezing nights of autumn occurs before the opening of the rabbit-hunting season, the tularemia rate among humans in the state is much lower than in other years. Green (1935, 1939) had previously pointed out that in Minnesota rabbits are free of tularemia during the cold months of the year and had suggested delaying the hunting of rabbits until middle or late October as a way of reducing the hazard of tularemia in human beings.

The Illinois records on tularemia and weather for the decade following the publication of the writers' first reports appear to support the conclusion that the tularemia rate and weather are closely related. Also, as was previously indicated (Thompson & Yeatter 1941), it is evident that the tularemia rate in Illinois may be influenced strongly at times by fluctuations of rabbit populations. The principal conclusion resulting from the present study is that, because of certain characteristics of the life history of the principal arthropod vector, the incidence of human tularemia in Illinois can be lowered significantly by delaying the opening of the rabbit-hunting

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†The Mearns cottontail rabbit, *Sylvilagus floridanus mearnsi* (Allen), is the common rabbit in Illinois. South of the Ozarkian Uplift, in extreme southern Illinois, its range intergrades with that of the Oklahoma cottontail rabbit, *S. f. alacer* (Bangs), according to Hamilton (1943). Other Lagomorpha in Illinois are the swamp rabbit, *Sylvilagus aquaticus aquaticus* (Bachman), distributed in wooded bottomlands of a few southern counties, and the white-tailed jack rabbit, *Lepus townsendii campianus* Hollister, which occurs in small numbers in the northwestern part of the state.



Fig. 1.—A Mearns cottontail rabbit. This rabbit is an important game animal throughout its range from New York to Kansas. In Illinois, it is the reported source of more than 90 per cent of the human tularemia cases.

season until about December 1. Such delay is urgent, particularly in the central and southern parts of the state.

Acknowledgments

The writers are greatly indebted to the Illinois Department of Public Health for detailed records since 1926 on the distribution of tularemia cases in Illinois and to the United States Public Health Service for information on the prevalence of tularemia in other parts of the country. They are indebted also to the Wisconsin Conservation Department for permission to use its records of the annual kill of cottontail rabbits in Wisconsin, to the United States Forest Service for census data on a southern Illinois area, and to Joe L. Mote of Watseka, Illinois, for bag records and field notes.

History of Tularemia

Tularemia was discovered in 1910 by Dr. George W. McCoy of the United States Public Health Service in the ground squirrels of Tulare County, California (McCoy 1911; Francis 1937). The disease was named in 1920 by Dr. Edward Francis (1921, 1937), also of the United States Public Health Service, after he had established the identity of the ground squirrel disease with an outbreak of "Deerfly fever" in man in Utah. The essential facts about tularemia have been worked out entirely by American investigators. The causative organism is a bacterium, *Pasteurella tularensis* (McCoy & Chapin) Bergey *et al.* (McCoy & Chapin 1912; Breed, Murray, & Hitchens 1948). In spite of the short history of tularemia, it is believed that this disease is not new but

is an old one which was not identified until comparatively recent years. Since 1925 it has been reported from all states except Vermont, as well as from Canada, Alaska, Mexico, and several countries in Europe, Asia, and Africa.

Tularemia in Wildlife

Burroughs *et al.* (1945) have listed 47 kinds of mammals and birds, distributed chiefly in North America, Europe, and Asia, in which natural infection with tularemia has been shown by laboratory tests. Various groups of lagomorphs and rodents make up more than three-fourths of their list. Also included are certain gallinaceous birds, raptorial birds, and carnivores, as well as a few domestic animals.

A few years ago, wildlife pathologists of the University of Minnesota and the United States Bureau of Biological Survey (now the Fish and Wildlife Service), co-operating with the Minnesota Department of Conservation, studied the relation of tularemia to the welfare of several wildlife species in Minnesota. As a result of these studies, Green (1939) reported that cottontail rabbits are highly susceptible to tularemia, and that infected cottontails invariably die, usually within a week after the onset of the disease. He found that snowshoe hares are resistant to the disease and that they seldom die from it. Jack rabbits prove rather susceptible when exposed, but, among wild jack rabbits in Minnesota, tularemia is apparently rare.

Green & Wade (1929) reported a fatal tularemia infection in the bob-white, *Colinus virginianus* Linnaeus; Green & Shillinger (1932) found the disease in the ruffed grouse, *Bonasa umbellus togata*, and the sharp-tailed grouse, *Pediocetes phasianellus*. Green (1939) stated that the ring-necked pheasant is highly resistant to infection, but that muskrats "suffer from a highly fatal infection." He reported that all kinds of mice, squirrels, and other small rodents in Minnesota are susceptible, and suggested that mice may be an important reservoir of the disease in the wild.

Green & Wade (1928) found that domestic cats contracted tularemia when fed the carcasses of infected guinea pigs. Green (1942) stated that dogs appear to

be almost entirely immune. Waller (1940), however, reported agglutination tests positive for tularemia in blood samples of a dog which became sick after feeding on a diseased rabbit. Downs *et al.* (1946) were successful in infecting a number of laboratory dogs by injection of virulent tularemia organisms, but reported that dogs were less susceptible to the disease than most laboratory animals and that they were often able to localize the infection.

Lillie & Francis (1936) reported as follows on attempted experimental inoculation of red foxes: "In 1934 four red foxes (*Vulpes fulva*) were obtained. One (7484) was injected subcutaneously with infected guinea pig spleen and culture (Omo strain), and died 13 days later. He refused to eat during the entire period. There was a diarrhea during the last 2 days of life. Two other foxes died 2 months after the subcutaneous inoculation of 7760 and after the first infectious feeding of 7761. Both of these animals had had noisy labored respiration; the first for some 4 weeks, the second for 3 or 4 days before death.

"*B. tularensis* was recovered directly from the blood of 7484, and inoculation of various organs of all three reproduced tularemia in guinea pigs and cultures were recovered."

Human beings sometimes become infected with tularemia through being bitten, scratched, or clawed by dogs, cats, or other flesh-eating animals that have become contaminated with the tissue or blood of infected wildlife.

A considerable number of animal species in which natural infection has not been proved have been reported as probable sources of human tularemia. Francis (1937) mentioned as suspected carriers the coyote, red fox, deer, ground hog, tree squirrel, skunk, sage hen, bull snake, and hog. Of domestic rabbits, Francis stated, "Rabbits raised under domestic conditions in rabbitries and hutches, although highly susceptible, have not been found naturally infected, due probably to their freedom from ticks."

Tick and Insect Vectors

Tularemia is spread among wild animals largely by the bites of ticks and insects.



Fig. 2.—Rabbit tick, *Haemaphysalis leporis-palustris* (Packard). Top, male; center, female; bottom, female, engorged. The rabbit tick is the chief agent in the spread of tularemia among rabbits and is an important carrier of the disease in other kinds of wildlife.

Infection in carnivorous mammals and birds may, of course, come from eating diseased prey. Also, it seems probable that certain aquatic mammals, and possibly other forms, sometimes contract the disease from water that is contaminated with *Pasteurella tularensis*. For example, the findings of Jellison *et al.* (1942) suggest that water-borne disease organisms were the source of a tularemia outbreak among beavers in Montana in 1939 and 1940.

Studies by Parker *et al.* (1951) indicate that contamination of streams and mud with tularemia organisms is widespread in the northwestern United States, and that fatal infections of muskrats and beavers with tularemia probably have occurred there in recent years.

The rabbit tick, *Haemaphysalis leporis-palustris* (Packard), fig. 2, is the chief arthropod vector of tularemia in the wild. Francis (1937) stated, "The disease . . . is spread from rabbit to rabbit principally by the rabbit tick, *Haemaphysalis leporis-palustris*, but also by other blood-sucking arthropods—ticks, lice, and fleas. The rabbit tick, the rabbit louse, and the rabbit flea do not bite man, and therefore they are not a source of human infection."

Green (1942) reported that the rabbit tick was principally responsible for the spread of tularemia among wild animals and birds in Minnesota.

Two other ticks, the American dog tick, *Dermacentor variabilis* (Say), fig. 3, and the Rocky Mountain wood tick, *D. andersoni* Stiles, fig. 4, are known vectors of tularemia. Both are sources of the disease in man as well as in various species of wildlife. The American dog tick, *D. variabilis* (also called wood tick), is distributed in the eastern United States, in the Mississippi River valley, and in some of the Plains states as well as in western California, Canada, and Alaska (Cooley 1938). Green (1942) reported that the most common mode of human tularemia infection in Minnesota appeared, at the time he wrote, to be the bite of a "wood tick" (American dog tick) and the second most common the cleaning of an infected rabbit. He found that the adult dog ticks that carry tularemia are those that have become infected during immature stages while feeding on diseased mice or other small rodents.



Fig. 3.—American dog tick, *Dermacentor variabilis* (Say). Top, male; center, female; bottom, female, engorged. This tick is widely distributed in North America; its principal range is east of the Rocky Mountains. It is a source of tularemia in humans and probably in various wild and domestic animals.



Fig. 4.—Rocky Mountain wood tick, *Dermacentor andersoni* Stiles. Top, male; bottom, female. This tick is a source of tularemia in humans and probably in domestic animals and wildlife. It is found in western parts of the North American continent.

Bell (1945) reported that a natural barrier, apparently a bactericidal action of the ticks' guts, keeps infection among dog ticks at a relatively low level. Green (1942) reported a maximum of only 1 infected to about 2,500 uninfected dog ticks in numerous tick samples collected in Minnesota. He noted that dog ticks in Minnesota go into a resting period in July and remain dormant until the following spring, and that they cause infection principally in May and June, just previous to becoming dormant.

The Rocky Mountain wood tick is distributed in southwestern Canada and in the western United States from the arid zone east of the Rocky Mountains westward to central Washington, central Oregon, and eastern California. Both immature and adult stages have been found

on a wide variety of mammals and birds (Cooley 1938). The adult stage has been reported as a source of human tularemia in several western states. Wood ticks are believed to have caused a tularemia outbreak among range sheep in Montana (Philip, Jellison, & Wilkins 1935).

Several kinds of insects are known to be carriers of tularemia. Prince & McMahon (1946) stated that the disease has been transmitted under experimental conditions by the bites of several insects, including deer flies, *Chrysops discalis* Williston, stable flies, *Stomoxys calcitrans* (Linnaeus), bed bugs, *Cimex lectularis* Linnaeus, and mosquitoes, *Aedes aegypti* (Linnaeus).

Lice and fleas, mentioned as vectors by Francis (1937), appear to be potentially important in the dissemination of tularemia in the northern states because they remain active in winter when most arthropod vectors are dormant. Ecke (1948) found that flea populations on Illinois cottontails were higher in winter than at other seasons. Evidence apparently is lacking, however, that either fleas or lice frequently transmit tularemia. Prince & McMahon (1946) reported that guinea pigs used in their transmission experiments remained negative for tularemia after exposure during 32 days to infected rat fleas, *Xenopsylla cheopis* (Rothschild), and California ground squirrel fleas, *Diamanus montanus* (Baker). They concluded that the two species of fleas tested do not play an important role in the spread of the disease. Green (1942) stated, "Fleas are found on rabbits in southern Minnesota during the winter; but, although these insects can transmit tularemia, they appear to do so rarely."

Hopla (1951) found that tropical rat mites, *Bdellonyssus bacoti* (Hirst), retained tularemia organisms for considerable periods after feeding on infected mice. Normal mice became infected when they crushed infected mites orally, but not when they were bitten by the mites.

Tularemia in Man

Francis (1937) stated that wild rabbits and hares are the source of more than 90 per cent of all human tularemia cases in the United States. Humans generally

become infected from contact of the bare hands with the flesh or blood of infected rabbits or from eating infected rabbit flesh that is insufficiently cooked. Usually infection from handling a diseased rabbit develops at the site of a scratch or puncture in the skin, but occasionally it develops in the eye as a result of contact with hands or of spattering of washings during cleaning. There is considerable evidence that the disease organism also is able to penetrate the unbroken human skin.

Francis (1937) described a typical tularemia case as follows: "About 3 days after exposure to infection, illness begins with headache, chilliness, vomiting, aching pains all over the body, and fever. The patient thinks that he has the 'flu' and goes to bed. The sore on the hand develops into an ulcer. The glands at the elbow or in the armpit become enlarged, tender, and painful, and later may develop into an abscess. There is sweating, loss of weight, and debility. Illness lasts about 3 weeks and is followed by a slow convalescence covering a period of 2 or 3 months. Most patients recover without any bad after effects, but about 5 percent die, especially if the case is complicated by pneumonia." Although there is no evidence of a natural immunity in man, persons who have recovered from the disease are permanently immune.

In regard to the diagnosis of the disease, Francis (1937) wrote: "The history of tick-bite, fly-bite, or wild rabbit contact especially, or contact with other animals, when coupled with fever, an ulcer on the skin, and regional lymph-node enlargement, should call attention to tularemia. Diagnosis is made conclusive by obtaining agglutination of *Bacterium tularense* [*Pasteurella tularensis*] by the patient's serum or by obtaining a culture of the organism from the patient's ulcer or lymph nodes following guinea pig inoculation, or by obtaining a positive skin reaction using an antigen prepared by Foshay of Cincinnati for intradermal injection."

As will be discussed later, treatment of tularemia in man has been facilitated in recent years by the use of antibiotics.

Distribution in the United States.—It will be evident from fig. 5, showing the distribution of 23,921 cases of tularemia reported in the United States during

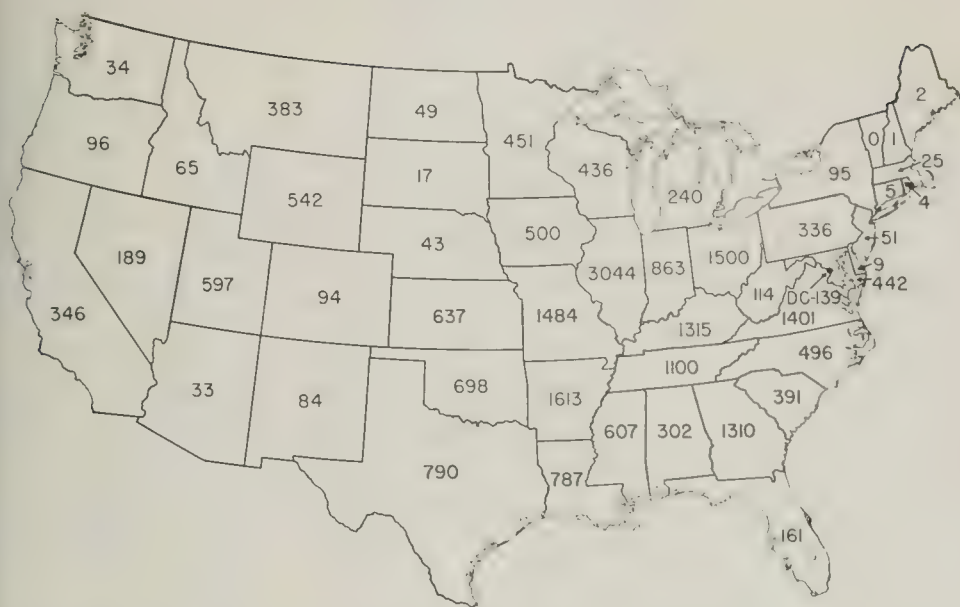


Fig. 5.—Total numbers of reported human tularemia cases in the various states during the period 1924–1949. Data from records of the United States Public Health Service.

the period 1924–1949, that the largest number of cases occurred in states lying in the central and south central portions of the eastern half of the country. Jellison & Parker (1945), who emphasize the importance of cottontail rabbits as a source of tularemia in humans, pointed out that

Table 1.—States that reported a total of 500 or more cases of tularemia, 1924–1949.*

STATE	NUMBER OF CASES
Illinois.....	3,051
Arkansas.....	1,613
Ohio.....	1,500
Missouri.....	1,484
Virginia.....	1,401
Kentucky.....	1,315
Georgia.....	1,310
Tennessee.....	1,100
Indiana.....	863
Texas.....	790
Louisiana.....	787
Oklahoma.....	698
Kansas.....	637
Mississippi.....	607
Utah.....	597
Wyoming.....	542
Iowa.....	500

*Data from United States Public Health Service records except Illinois figure, which is from Illinois Department of Public Health and higher than figure from federal agency.

cottontails and closely related forms are the only kinds of wild rabbits native to much of the region mentioned above.

The states which, according to the records of the United States Public Health Service, reported 500 or more cases of tularemia in the period 1924–1949 are listed in table 1. Illinois, with more than 3,000 cases, reported the largest number, followed by Arkansas with 1,613 and Ohio with 1,500 cases. Although Illinois had the largest human population among the 17 states listed, more than one-half of all tularemia cases reported in Illinois in 1936–1949 were from counties in the southern third of the state, which had only about 12 per cent of the state's population.

Preliminary studies indicated that the human tularemia rate in Illinois and nearby states tended to fluctuate, but it was evident that the particular years in which increases, or decreases, occurred often were not the same in all parts of a geographic region. For example, in one year, 1938, there was a decline of about 50 per cent in the tularemia rate in the northern Great Lakes states, but at the same time there was a severalfold increase in Illinois and the regions adjoining it on the east and west. Later, in 1941,

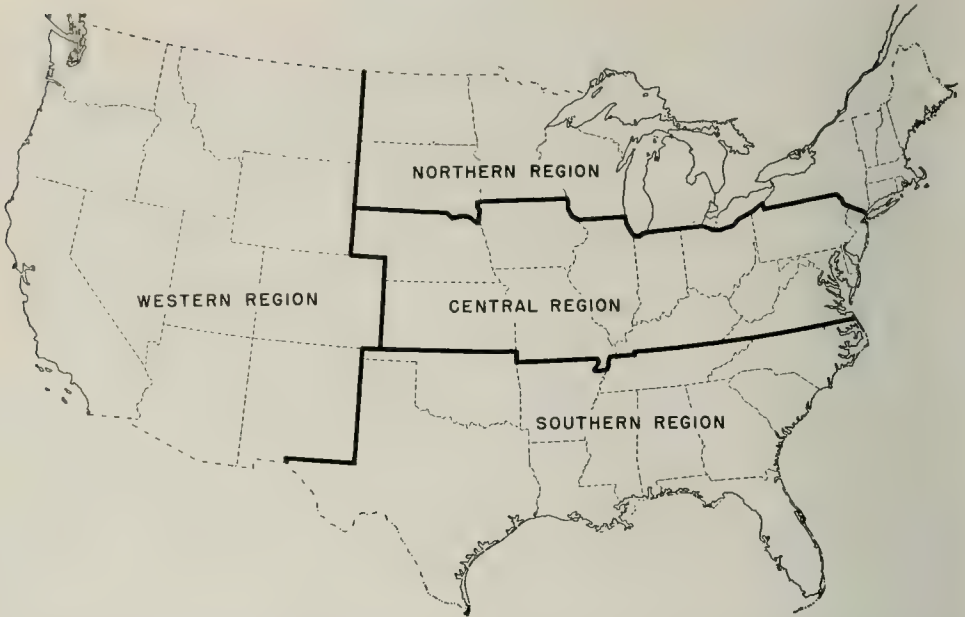


Fig. 6.—Four general regions of the United States which exhibit distinctive trends and seasonal distribution of human tularemia.

when tularemia declined in Illinois, Indiana, and Iowa, there was a moderate increase in the states to the north.

With respect to human tularemia rates and seasonal distribution, the United

States may be divided conveniently into four major regions, namely, Northern, Central, Southern, and Western, fig. 6. Trends in the annual tularemia rates during the period 1935–1949 in these four

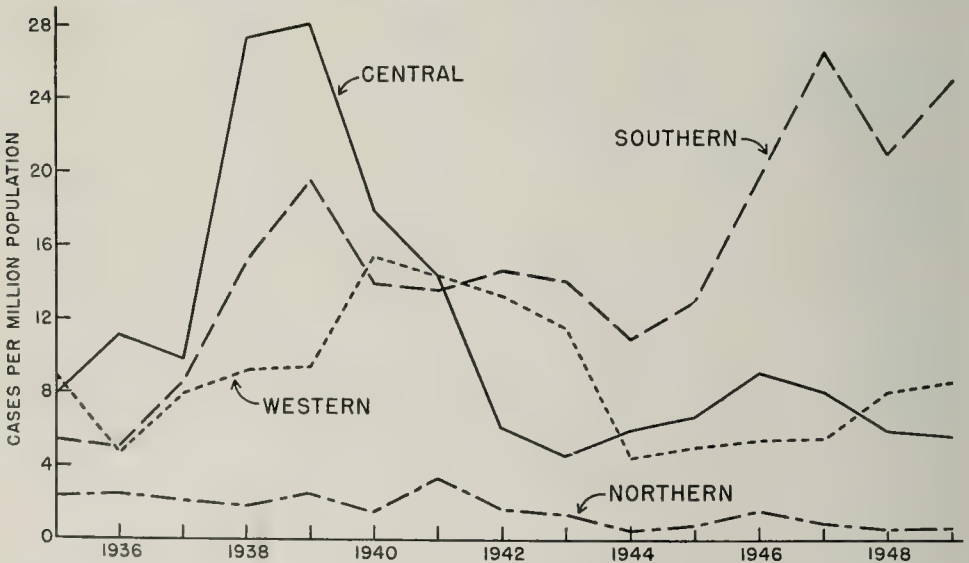


Fig. 7.—Trends in human tularemia rates during the period 1935–1949 in the four regions of the United States shown in fig 6. Data on which this graph is based are from records of the United States Public Health Service.

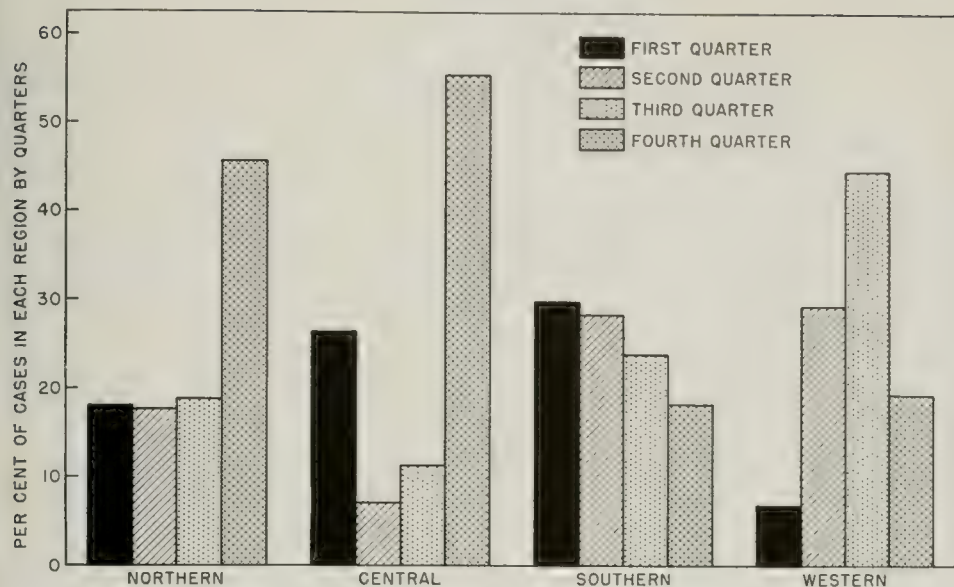


Fig. 8.—Distribution of reported human tularemia cases by quarters of the year during the period 1939-1949 in the four regions of the United States shown in fig. 6. Data on which this graph is based are from records of the United States Public Health Service.

regions are shown in fig. 7. The seasonal distribution of tularemia in these regions is shown in table 2 and fig. 8.

In the Northern and Central regions the majority of cases occur during late autumn and early winter. Rabbits, which are hunted at that time, cause most of the cases. As indicated by table 3, furbearers, squirrels, and upland game birds contribute a few cases. During other seasons, these regions show moderate numbers of cases that, presumably, result from bites of ticks or insects, from chance infections by a variety of mammals or birds, both wild and domestic, or from a small amount of year-round hunting.

In the Southern Region, the human tularemia rate is fairly uniform throughout the year, indicating several sources of infection, the most important of which are rabbits, ticks, and insect vectors. Francis (1937) recorded 65 cases of tularemia in the southern states, chiefly from March through July, due to contact with dog ticks, *Dermacentor variabilis*. Pullen & Stuart (1945) reported that 176 (92.1 per cent) of 191 tularemia cases for which the apparent source was recorded in Louisiana during a 16½-year period gave a history of contact with rabbits. In this

region, year-round hunting probably plays an important part in transmission of tularemia to human beings.

The human tularemia rate in the Western Region is highest in summer. Because the principal insect and tick vectors in this region are most active from late spring to late summer, it appears that arthropods may play a relatively greater part in transmitting tularemia to humans there than in the Northern and Central regions. Wood ticks, *Dermacentor andersoni*, were reported by Francis (1937) to have caused more than 50 cases in Montana and surrounding states. According to the United States Public Health Service (Anonymous 1940), sheep handlers have occasionally become infected from contact with wood ticks or tick feces in the wool. Jellison (1950) listed, for the western states, 158 cases of tularemia probably caused by deer fly bites, and showed that the distribution of these cases corresponded roughly with the distribution of the deer fly species, *Chrysops discalis* Williston. Jellison *et al* (1950) reported contamination with *Pasteurella tularensis* organisms of certain natural waters in Montana and also a few cases of human tularemia caused by a contaminated domestic water supply.

Table 2.—Summary of reported tularemia cases in four major regions of the United States, by quarters and years, 1939-1949. (Data from annual reports of the United States Public Health Service on the incidence of communicable diseases.)

Year	NORTHERN REGION ¹					CENTRAL REGION ²					SOUTHERN REGION ³					WESTERN REGION ⁴				
	Quarter				Total for Year	Quarter				Total for Year	Quarter				Total for Year	Quarter				Total for Year
	1	2	3	4		1	2	3	4		1	2	3	4		1	2	3	4	
1939.....	5	9	9	57	80	291	36	90	1,007	1,424	209	153	101	142	605	12	29	57	30	128
1940.....	10	8	11	24	53	368	45	78	444	935	176	103	86	74	439	10	70	105	29	214
1941.....	21	15	15	64	115	127	37	68	509	741	105	121	111	90	427	12	68	86	33	199
1942 ⁵	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1943.....	6	11	16	16	49	91	32	38	77	238	134	167	90	50	441	6	70	64	19	159
1944.....	6	4	4	4	18	40	18	32	220	310	78	121	95	49	343	3	16	34	9	62
1945.....	6	4	11	7	28	117	36	46	150	349	116	102	112	78	408	3	25	32	11	71
1946.....	11	12	9	24	56	76	44	56	294	470	152	143	176	148	619	11	22	25	17	75
1947.....	11	5	10	6	32	180	52	84	106	422	261	233	201	120	815	6	13	37	20	76
1948.....	3	9	2	6	20	82	29	63	130	304	146	230	147	134	657	6	17	55	34	112
1949.....	6	7	2	8	23	74	54	62	100	290	266	203	197	119	785	14	26	47	33	120
Total.....	85	84	89	216	474	1,446	383	617	3,037	5,483	1,643	1,576	1,316	1,004	5,539	83	356	542	235	1,216

¹Northern Region: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Michigan, Wisconsin, Minnesota, North Dakota, South Dakota, Kansas.

²Central Region: New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, Virginia, West Virginia, Ohio, Indiana, Illinois, Kentucky, Iowa, Missouri, Nebraska, Kansas.

³Southern Region: North Carolina, South Carolina, Georgia, Florida, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas.

⁴Western Region: Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, California.

⁵Records for 1942 are omitted because quarterly summaries are lacking. The total numbers of reported cases for 1942 are as follows: Northern Region, 58; Central Region, 317; Southern Region, 464; Western Region, 185.

Jack rabbits, *Lepus* spp., are the reported source of a number of cases in the Western Region. These rabbits also are important hosts of ticks and probably of biting flies that carry the disease (Jellison & Parker 1945). Jellison (letter of April 24, 1951, from Hamilton, Montana) states, "Cottontails have not been as important in this area as other sources of infection."

Distribution in Illinois.—Records of the Illinois Department of Public Health indicate that cottontail rabbits are responsible for the great bulk of human tularemia in Illinois. According to Sharp (1939) all but 2 of 459 reported cases in the state in 1938, during a severe outbreak of the disease, were traceable to contact with cottontail rabbits. McDaniels (1943) stated that cottontails cause more than 95 per cent of the human tularemia cases in Illinois. Other mammals, birds, ticks, and blood-sucking insects probably serve as the source of infection for most of the other cases, as numerous infections have been traced to them elsewhere in the United States.

Recent studies by Jackson (1946) in Indiana and Morgan (1949) in Wisconsin, table 3, show somewhat higher percentages of cases caused by vectors other than rabbits reported for these states than for Illinois. As has already been shown, the proportion of tularemia cases caused by the several kinds of known vectors varies with different sections of the country.

The mortality rates from human tularemia cases reported in Illinois during the period 1926–1951 averaged 5.7 per cent, table 4. Considerable variation in the mortality rates was apparent from year to year. It is of interest in this regard that Philip & Davis (1935), Green (1943), and others isolated several strains of tularemia from naturally infected animals. These strains differed widely in virulence. Green's work indicated that the virulence of the disease depended largely on the kind of animal from which it came. For example, he found that the virulence of tularemia from infected grouse was considerably lower, when measured by the

Table 3.—Reported sources of human tularemia in Wisconsin (379 cases in which the cause was reported) and Indiana (123 cases). Data from Morgan (1949) and Jackson (1946).

REPORTED SOURCE OF INFECTION	WISCONSIN		INDIANA	
	Number of Cases	Per Cent of Total	Number of Cases	Per Cent of Total
MAMMAL.....	340	89.7	117	95.1
Rabbit.....	305	80.5	108	87.8
Muskrat.....	10	2.6	2	1.6
Cat.....	9	2.4	1	0.8
Dog.....	8	2.1	—	—
Squirrel.....	4	1.1	5	4.1
Skunk.....	2	0.5	—	—
Horse.....	2	0.5	—	—
Opossum.....	—	—	1	0.8
UPLAND GAME BIRD.....	11	2.9	1	0.8
Partridge, pheasant, or prairie chicken	11	2.9	—	—
Pheasant.....	—	—	1	0.8
ARTHROPOD.....	27	7.1	5	4.1
Tick.....	24	6.3	4	3.3
Deer fly.....	3	0.8	—	—
Sweat bee.....	—	—	1	0.8
WATER.....	1	0.3	—	—
Total.....	379	100.0	123	100.0

Table 4.—Data on human tularemia reported by the Illinois Department of Public Health 1926–1951.

YEAR	CASES	DEATHS	PER CENT MORTALITY
1926.....	1	—	—
1927.....	14	—	—
1928.....	10	—	—
1929.....	36	1	2.8
1930.....	139	2	1.4
1931.....	126	4	3.2
1932.....	134	4	3.0
1933.....	172	9	5.2
1934.....	134	11	8.2
1935.....	69	4	5.8
1936.....	91	6	6.6
1937.....	109	5	4.6
1938.....	459	32	7.0
1939.....	485	42	8.7
1940.....	272	23	8.5
1941.....	106	6	5.7
1942.....	67	1	1.5
1943.....	55	1	1.8
1944.....	91	10	11.0
1945.....	131	6	4.6
1946.....	97	9	9.3
1947.....	123	1	0.8
1948.....	57	2	3.5
1949.....	73	0	0.0
1950.....	80	2	2.5
1951.....	74	0	0.0
Total....	3,205	181	—
Average.	—	—	5.7

survival time of inoculated guinea pigs, than that from rabbits. After serial passage of these strains through guinea pigs, however, the virulence of the two strains became identical.

According to a publication of the Illinois Department of Public Health (Anonymous 1939) tularemia in man "may be mild in character although greatly reducing physical efficiency. For that reason a great many cases undoubtedly escape notification. . . . [The disease is] probably considerably more prevalent in Illinois than case reports indicate."

Hicks (1942) has suggested that some rabbit hunters, as a result of mild infections, may acquire a degree of immunity to tularemia. He wrote: "If there is such a thing as partial or complete immunity, it may be due to a former infection so mild as to have gone unrecognized, or, more likely, to resistance acquired by frequent but slight inoculations obtained through being bitten by ticks or other vectors."

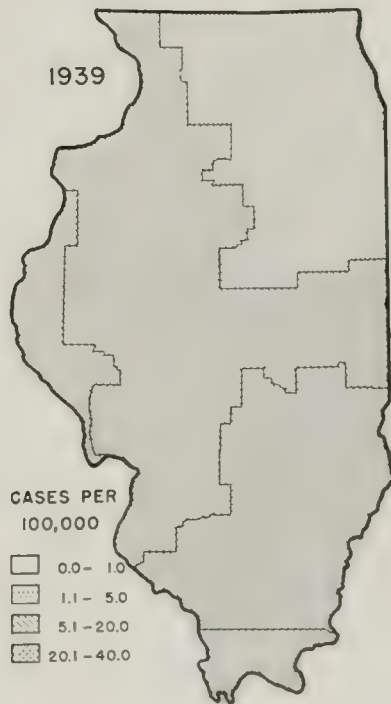
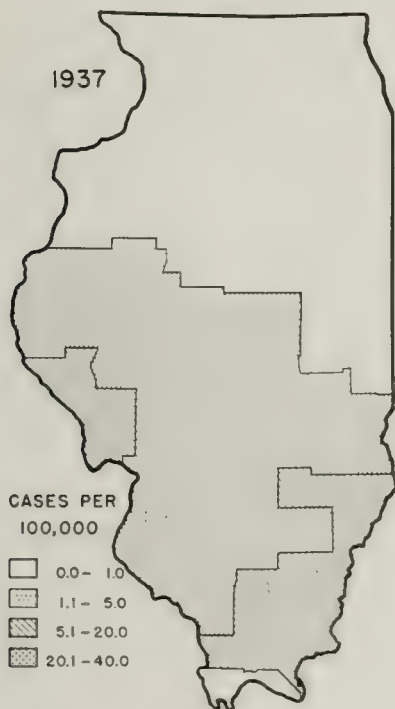
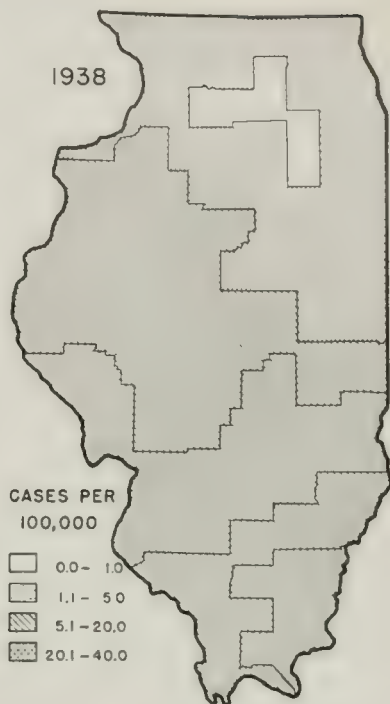
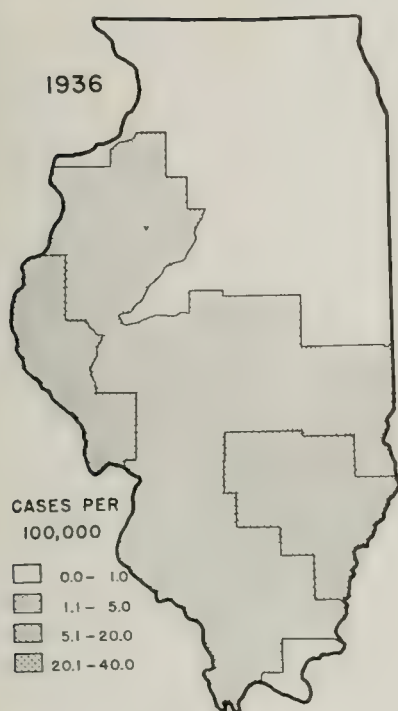
The first known case of human tularemia in Illinois was reported in 1926. By 1930 the annual total of reported cases exceeded 100. A summary of the data on tularemia in Illinois during the period 1926–1951 is shown in table 4. The small number of cases reported early in this period probably reflects lack of experience on the part of many physicians in identifying the disease.

The distribution of human tularemia in Illinois in each year of the 14-year period 1936–1949 (the years of most intensive study of rabbit populations in relation to incidence of human tularemia) is presented in figs. 9–22. Because the number of cases in most counties was too small to be treated statistically, and because hunters commonly go into neighboring counties to hunt, the data have been "smoothed" in order to determine general trends in prevalence of the disease over the state. This "smoothing" of the data was done for each county by averaging the number of cases and the populations with comparable data for all adjoining counties.

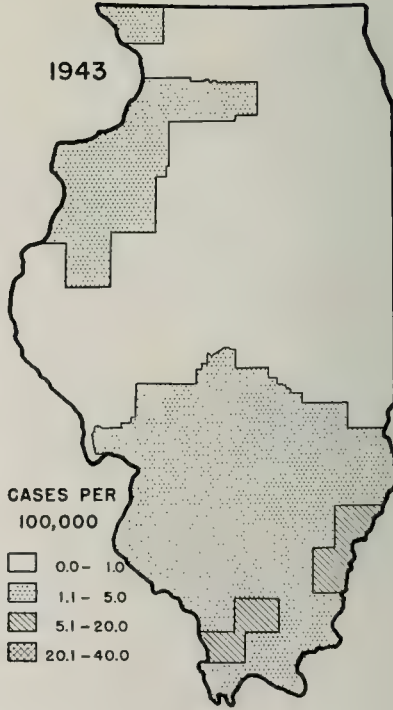
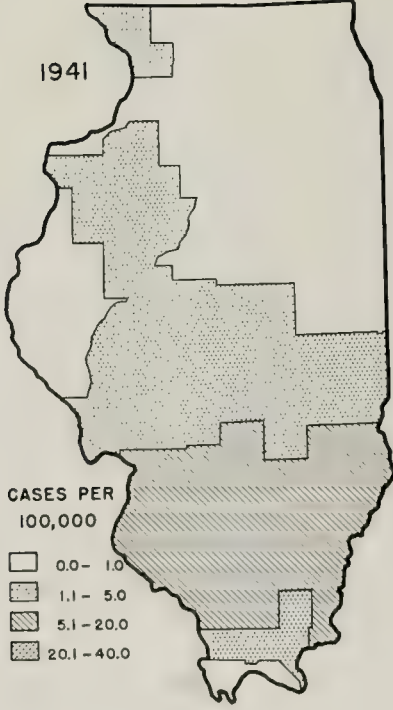
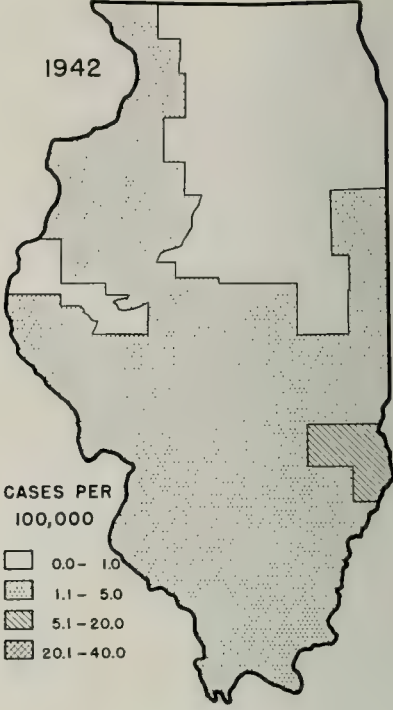
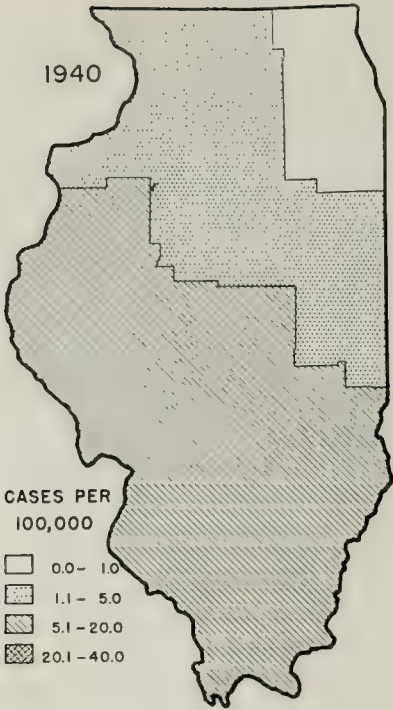
When the tularemia rate was calculated on the basis of numbers of hunting licenses sold in the various counties, rather than the total population, the trends were essentially the same and need not be shown here.

An inspection of the 14 maps in figs. 9–22 shows that tularemia rates among humans in the south and central parts of the state are much higher than in the northern part. In each of these years there were blocks of counties in the south central region where the rates were 10 to 20 times as great as in the northeast part of the state. Areas of highest rates follow about the same pattern from year to year and are located in two general regions: (a) a region consisting of 15 to 25 counties in the southeast part of the state and (b) a region consisting of a smaller block of counties along the lower course of the Illinois River and up the west side of the state along the Mississippi River.

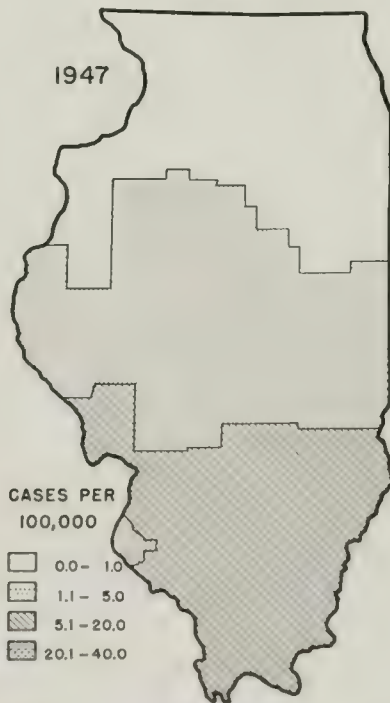
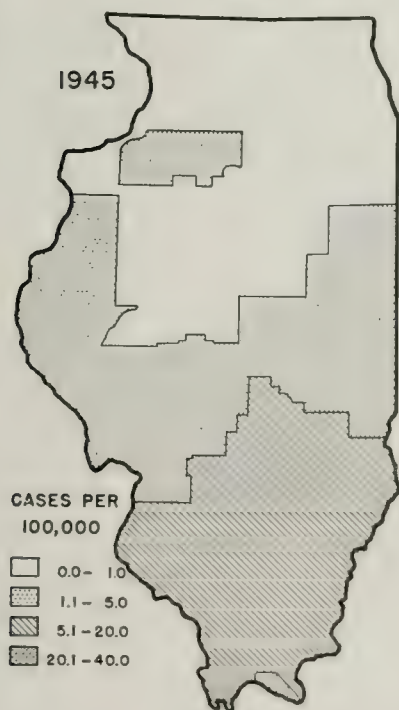
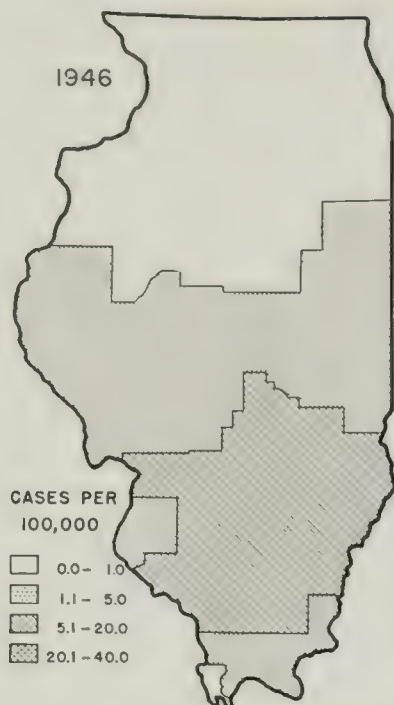
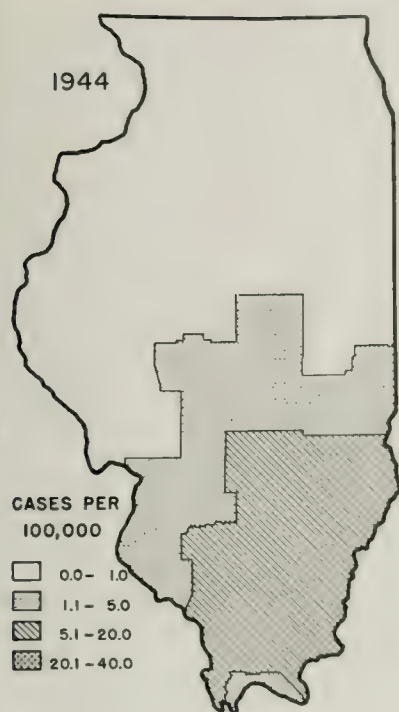
These regions correspond rather closely with the sections of the state listed by Case & Myers (1934) as having the highest percentages of idle land, that is, land not under cultivation. The first-named region consists for the most part of what is known as the gray soil prairie, where soils are light colored and fertility is relatively low.



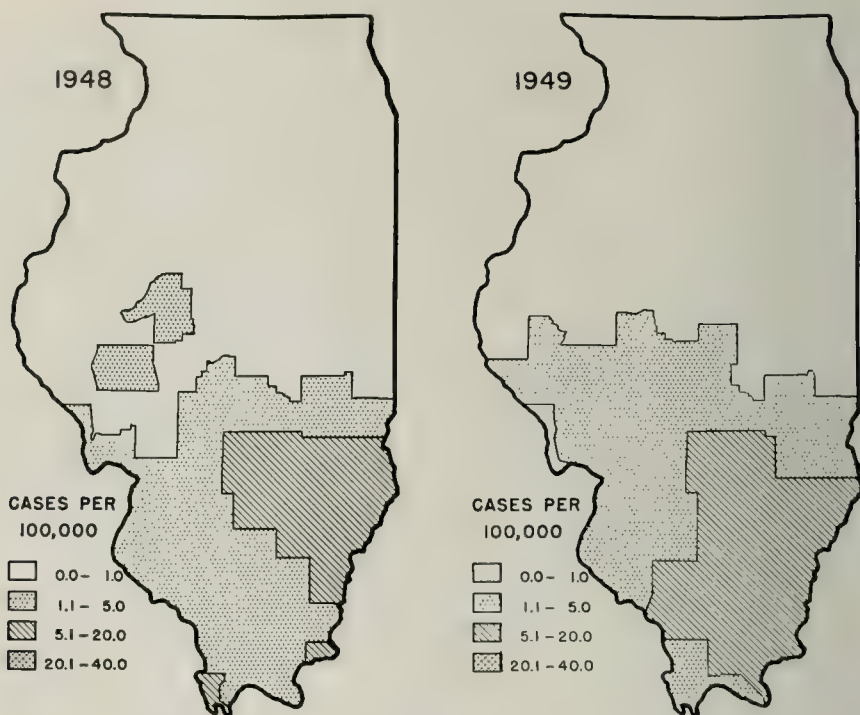
Figs. 9-12.—Distribution of human tularemia cases per 100,000 population in Illinois for the years 1936-1939.



Figs. 13-16.—Distribution of human tularemia cases per 100,000 population in Illinois for the years 1940-1943.



Figs. 17-20.—Distribution of human tularemia cases per 100,000 population in Illinois for the years 1944-1947.



Figs. 21-22.—Distribution of human tularemia cases per 100,000 population in Illinois for the years 1948-1949.

Here, there are scattered wood lots, overgrown stream banks, hedges, and, during periods of low agricultural prices, many fields that are allowed to lie fallow for one or more years at a time. The second region is dissected by a number of small streams draining into the Illinois and Mississippi rivers. As a result, it has a high percentage of forested and uncultivated land.

The tularemia rates in the above-named regions are among the highest in the United States. The prevalence of tularemia in these regions probably is indirectly related to the comparatively high rabbit populations found there. Green, Evans, & Larson's (1943) study of rabbit tick populations on snowshoe hares in Minnesota showed that when hares were abundant the average number of ticks per hare was high, but when hares were uncommon the average number was low. Possibly both the relatively high rabbit populations and dense ground cover in extensive areas of southern Illinois favor the survival of rabbit ticks, thus contributing to the spread of tularemia.

Weather and Tularemia

The interrelationships of ticks and tularemia to the cottontail and snowshoe hare in Minnesota were studied in detail for a number of years by the late Dr. Robert G. Green and his associates. They found that rabbit ticks were the principal means by which tularemia was spread from rabbit to rabbit in Minnesota and that these ticks left the rabbits by mid-autumn to go into hibernation. Green, Evans, & Larson (1943) reported that most hares and rabbits were found free of ticks after November 1, although occasional individuals might carry ticks in December, January, and even in February.

Green (1935, 1939) reported that after cold weather has caused the ticks to leave the rabbits, and after an additional week during which infected cottontails die, hunting is comparatively safe. He recommended that hunting in Minnesota be delayed until middle or late October.

Earlier in this paper it was pointed out that in 1938 there was a marked decline

in human tularemia in the northern Great Lakes states and a great increase in Illinois and states adjoining it on the east and west. In Illinois there was a considerable increase in the number of rabbits between the autumn of 1937 and the autumn of 1938, but it did not seem great enough to account for the eightfold increase in the number of tularemia cases reported in the 1938 hunting season. Inasmuch as there had been no shifts in the date of opening of the rabbit season in any of the North Central states, it occurred to us that these changes in tularemia rates might be due to differences in temperatures about the time of the opening of the season, as well as to changes in rabbit abundance.

Although the percentage of infected rabbits apparently declines sharply throughout the state soon after November 11 (the opening date of the rabbit-hunting seasons in recent years) the peak month for cases reported to the Illinois Department of Public Health is December, table 5. It should be explained here that tularemia cases are usually listed for the month in which they are reported and not the month of infection. Francis (1937) cites 45 Illinois tularemia cases for which the exact month of onset is accurately recorded, as follows: October, 1 case; November, 23 cases; December, 18 cases; and January, 1 case. We suppose that the apparent discrepancy arises from (a) delays between killing and eating rabbits (cold storage or freezing does not prevent infection), (b) incubation period for the infection, (c)

Table 5.—Distribution of Illinois cases of human tularemia, by months, 1926–1949.

MONTH	CASES	PER CENT OF TOTAL
July.....	57	1.9
August.....	50	1.6
September.....	51	1.7
October.....	69	2.3
November.....	318	10.4
December.....	1,507	49.4
January.....	603	19.8
February.....	175	5.7
March.....	76	2.5
April.....	46	1.5
May.....	53	1.7
June.....	46	1.5
Total.....	3,051	100.0



Fig. 23.—The three hunting zones of Illinois established by the state Game Code and the location of United States weather stations whose records were used in this paper as representative of each zone.

delay in consulting a physician, (d) time for making the diagnosis, and (e) time for making the report after diagnosis.

To learn whether the prevalence of human tularemia in Illinois is associated with temperatures preceding the opening of the rabbit season, we correlated the number of cases reported in the November–February period following the opening of each hunting season, 1926–1949, with the mean or average date of the first 10 freezing nights. A freezing night was defined arbitrarily as 27 degrees F. or colder. This method of studying the relation of the incidence of human tularemia to weather was devised several years ago by the writers (Anonymous 1941). It appears to result in a more satisfactory

correlation than any of several other methods that were tried.

Illinois, with a north-south length of almost 400 miles, has striking differences in climate, and for that reason the game and fish codes recognize three zones of about equal area: Northern, Central, and Southern. For making comparisons of the mean dates of the first 10 freezing nights, we chose a representative weather station located near the center of each of these zones. The Sycamore, Springfield, and McLeansboro stations have records covering long periods of years and are not in deep valleys or near large bodies of water. The three zones and the locations of these weather stations are shown in fig. 23.

When the numbers of days, between the mean or average dates of these first 10 freezing nights and the dates of the opening of the rabbit-hunting seasons are compared with the numbers of cases of human

tularemia for 24 successive years, 1926-1949, it is evident that there is a general correspondence in rises and falls between the two sets of data.

Table 6 shows the mean dates of the first 10 freezing nights for each zone in each of 24 autumns beginning in 1926, when tularemia was first reported in Illinois, as well as the opening dates of the rabbit-hunting season, the number of days between these dates in each year (the three zones averaged), and the numbers of tularemia cases in the November-February periods. The correspondence between the two curves is most striking in recent years, when recognition and reporting of the disease has been general, fig. 24.

For each year of the period 1936-1940, bracketing Illinois' greatest tularemia outbreak, data are available showing the distribution of cases by counties. These data make possible a comparison of average tula-

Table 6.—Dates of rabbit-hunting seasons, average or mean dates of first 10 freezing nights in autumn, and number of human tularemia cases reported in Illinois, 1926-1949. (N, C, and S indicate respectively the Northern, Central, and Southern hunting zones in Illinois as shown in fig. 23.)

YEAR	HUNTING SEASON FOR RABBITS	AVERAGE DATE OF FIRST 10 FREEZING NIGHTS (27° F. or Less)			DAYS AFTER OPENING OF SEASON TO MEAN DATE OF FIRST 10 FREEZING NIGHTS (AVERAGE FOR THREE ZONES)	TULAREMIA CASES REPORTED NOVEMBER- FEBRUARY
		N. Zone	C. Zone	S. Zone		
1926...	Nov. 10-Jan. 31	Nov. 11	Nov. 17	Nov. 13	3.9	1
1927...	Nov. 10-Jan. 31	Nov. 14	Nov. 25	Nov. 24	11.5	11
1928...	Nov. 10-Jan. 31	Nov. 17	Dec. 4	Dec. 1	17.5	9
1929...	Nov. 10-Jan. 31	Nov. 15	Nov. 26	Nov. 23	11.7	63
1930...	Oct. 1-Jan. 10	Oct. 27	Nov. 9	Nov. 16	38.5	149
1931...	Nov. 10-Jan. 31	Nov. 26	Dec. 23	Dec. 9	29.9	96
1932...	Nov. 10-Jan. 31	Nov. 2	Nov. 16	Nov. 19	2.7	141
1933...	Nov. 10-Jan. 31	Oct. 30	Nov. 14	Nov. 25	3.0	144
1934...	Nov. 10-Jan. 31	Nov. 16	Dec. 9	Nov. 25	16.9	117
1935...	(N) Nov. 10-Jan. 31	Nov. 4	Nov. 25	Nov. 22	-1.2	34
	(C) Nov. 20-Jan. 31					
	(S) Nov. 25-Jan. 31					
1936...	(N) Nov. 10-Jan. 31	Nov. 3	Nov. 23	Nov. 17	-3.5	103
	(C) Nov. 20-Jan. 31					
	(S) Nov. 25-Jan. 31					
1937...	Nov. 10-Dec. 31	Oct. 27	Nov. 22	Nov. 10	-0.4	64
1938...	Nov. 10-Dec. 31	Nov. 17	Dec. 1	Nov. 22	13.8	500
1939...	Nov. 10-Jan. 15	Nov. 10	Dec. 12	Nov. 14	12.7	451
1940...	Nov. 10-Jan. 15	Nov. 9	Nov. 19	Nov. 18	6.2	164
1941...	Nov. 10-Jan. 15	Nov. 18	Dec. 5	Nov. 27	16.9	70
1942...	Nov. 10-Jan. 15	Oct. 23	Nov. 27	Nov. 14	1.6	40
1943...	Nov. 11-Jan. 31	Nov. 9	Nov. 24	Nov. 20	7.5	24
1944...	Nov. 11-Jan. 31	Nov. 5	Dec. 6	Dec. 8	15.7	132
1945...	Nov. 11-Jan. 31	Nov. 9	Nov. 22	Nov. 29	9.9	60
1946...	Nov. 11-Jan. 31	Nov. 21	Dec. 5	Dec. 3	19.1	121
1947...	Nov. 11-Jan. 31	Nov. 12	Nov. 25	Nov. 29	11.6	35
1948...	Nov. 11-Jan. 31	Nov. 12	Nov. 18	Dec. 8	12.1	41
1949...	Nov. 11-Jan. 15	Nov. 9	Dec. 3	Nov. 29	13.2	58

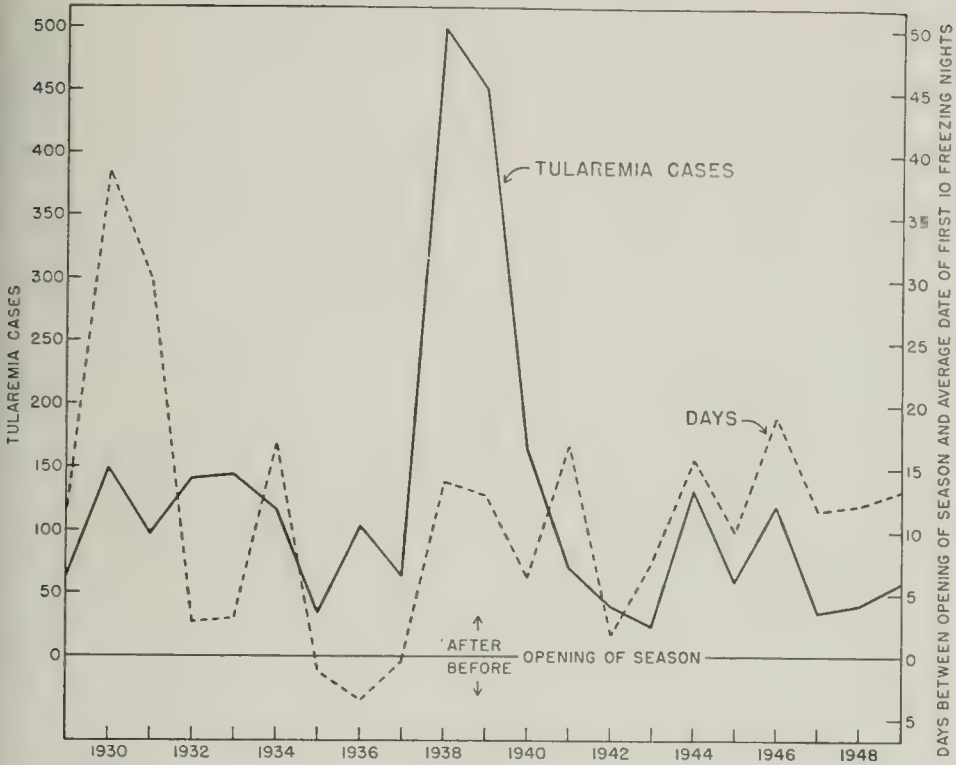


Fig. 24.—The number of cases of human tularemia per year in Illinois and the average date of the first 10 freezing nights in each autumn, 1929–1949.

remia rates in each of the three zones in each of those 5 years as they are related to the number of days between the opening date of the rabbit-hunting season and the mean date of the first 10 freezing nights. This 5-year period includes 1938 and 1939, when there was an epidemic of tularemia in Illinois, and 1936, 1937, and 1940, when the tularemia rate was about average. A summary is given in table 7.

Ecke's (1948) studies of ectoparasites on cottontails collected in central Illinois in the autumn of 1947 indicate that migration of rabbit ticks to hibernating places was at a peak in late October of that year and that the great majority of these ticks had left the rabbits to go into hibernation by the time of opening of the hunting season in early November. Temperatures were slightly above average in October and

Table 7.—Days from opening of rabbit-hunting season to average or mean date of first 10 freezing nights in autumn, number of hunting-zone-years represented, and tularemia rate in Illinois, 1936–1940. Figures on weather and human tularemia rate were obtained by averaging data for each zone separately.

DAYS FROM OPENING OF RABBIT-HUNTING SEASON TO MEAN DATE OF FIRST 10 FREEZING NIGHTS	NUMBER OF ZONE-YEARS AVERAGED	TULAREMIA RATE, CASES PER 100,000, NOVEMBER–FEBRUARY
30 to 39 days before.....	1	14.1
20 to 29 days before.....	1	14.2
10 to 19 days before.....	2	11.1
0 to 9 days before.....	7	4.3
0 to 9 days after.....	3	1.0
10 to 19 days after.....	1	0.4

November of that year. It seems probable that even though tick hibernation in central Illinois is usually well advanced by November 11, the opening date of the rabbit-hunting season in recent years, it is not complete. It is apparent that this date is too early to afford hunters the desired freedom from the danger of infection. Hibernation of ticks may be delayed by recurrence or persistence of warm weather; presumably it occurs somewhat later in southern Illinois, where the majority of tularemia cases are found, than in the central and northern parts of the state.

Portman (1944) reported finding rabbit ticks feeding on cottontails in the southern counties of Missouri during the winters of 1943 and 1944. He believed that southern Missouri is the approximate northern limit of the rabbit tick's year-round activity. Since the extreme southern counties of Illinois are close to and in approximately the same latitude as the Missouri areas where Portman did his collecting, it is possible that a certain amount of year-round activity of ticks occurs there also.

Although a fair number of Illinois hunters now delay their rabbit hunting until cold weather, apparently a great many still begin to take rabbits as soon as the season opens, believing that the animals will soon be thinned out and made wary by other hunters. The initial rush greatly emphasizes the importance of the date of opening of the season because this is the critical period for tularemia. No statistics are available in Illinois showing how much hunting is concentrated in the early days of the season, but we estimate that between one-third and one-half of the year's crop is taken in the first week.

In Ohio, Benjamin (1940) reported the daily kill of rabbits in the season of 1939 on 180,000 acres of state-supervised hunting areas scattered through 35 counties. A quarter of the season's total was killed on the opening day (November 8), and by the end of the fourth day (November 11) more than half had been killed. Incidentally, he found that the average daily kill per hunter was about twice as great on the opening day as it was 3 or 4 weeks later.

Burroughs & Dayton (1941) reported the daily kill of cottontails on 9,000 acres in Saginaw County, Michigan, in 1938 and 1939. In both seasons combined,

more than a third of the annual kill was made on the opening day and more than a half by the end of the first week.

All available evidence indicates that an early rabbit-hunting season, such as is now in effect in Illinois, results in the handling by hunters of approximately half of the rabbit kill at a time when the possibility of contracting the disease is still comparatively great.

Although it is apparent that temperatures just preceding the opening of the rabbit-hunting season play an important part in determining the amount of human tularemia in Illinois, the influence of weather, as has already been suggested, is frequently modified by another factor, the abundance of rabbits.

Rabbit Populations and Tularemia

The tularemia rate for the whole Central Region of the United States, fig. 6, increased from 9.8 cases per million inhabitants in 1937 to 27.3 cases per million in 1938 and 28.1 cases per million in 1939. The sharp rise in the tularemia rate during the period 1937-1939 occurred simultaneously with a marked increase in the numbers of cottontail rabbits in the Central Region, especially in the middle Mississippi and the lower Missouri river basins. Subsequently, following a general decrease of rabbits, the tularemia rate declined, and, by 1942, only 6.1 cases per million were reported in that region. This apparent relationship between the prevalence of tularemia and the high peak of rabbit populations emphasized the need for further information on the behavior of game populations.

Studies of animal populations in recent years have shown that many kinds of animals are subject to more or less regular variations in numbers. The snowshoe or varying hare, *Lepus americanus* Erxleben, is often cited as a classic example of an animal that undergoes cyclic fluctuations. MacLulich (1937) concluded from an analysis of population data, including records of the Hudson's Bay Company covering more than a century, that the cycles of the snowshoe hare in Canada have varied in length from 8 to 11 years and have averaged 9.6 years.

Although long-time population records,

such as have been used in studies of the snowshoe hare, are lacking for cottontail rabbits, records obtained by workers in several northern states indicate that cottontail populations tend to fluctuate rather widely. This paper does not attempt to arrive at final conclusions as to whether Illinois cottontail rabbits have cyclic, and thus possibly predictable, fluctuations. Nevertheless, it seems advisable to discuss briefly the available records of cottontail population trends in Illinois and nearby regions in recent years, because of the apparent relationship of the populations to the incidence of human tularemia.

Fig. 25 shows the annual kill of cottontails in Wisconsin during the period 1931-1949 as computed from hunters' reports to the Wisconsin Conservation Department (Anonymous 1949 and personal communication from W. E. Scott). Cottontail rabbits occur throughout Wisconsin except possibly in a narrow zone along the northern border, but they are generally most common in the southeastern counties (Morgan 1949). The curve in fig. 25 probably reflects the trend of the total Wisconsin cottontail rabbit population during the period 1931-1949. The trend of cottontail populations appears to have followed rather closely the trends of snowshoe hare and grouse populations in Wisconsin during the same period, as shown by Grange (1948).

Although the Illinois cottontail rabbit population data are not so nearly complete as the data for Wisconsin, records from the Natural History Survey and other sources have made possible a partial reconstruction of the fluctuations of cottontail rabbit populations in the state during 25 recent years. These data include, in addition to field notes and published records, replies of sportsmen to questionnaires, estimates of rabbit populations in southern Illinois by the United States Forest Service, information received annually by the Natural History Survey on rabbit damage to crops and orchards, and bag records and field notes of qualified hunter-observers. Because these data refer to different regions, they show something of the local aspects of population fluctuations in Illinois. As already indicated, local fluctuations are important in considering the relation of rabbit abundance to human tularemia rates.

The most noteworthy feature of the behavior of Illinois cottontail rabbit populations during the quarter century was the sharp increase in numbers during the late 1930's, culminating in 1938 and 1939 in the highest populations in many decades. The increase of rabbits in Illinois was most evident in the southern half of the state, where the main endemic centers of tularemia are found. As has been mentioned, nearly 1,000 cases of human tularemia were reported in Illinois during 1938 and 1939. Unusually high rabbit populations during these years were reported also in Iowa, Missouri, Kansas, Arkansas, and some other central states, where the tularemia rate also showed a sharp rise. Dur-

Table 8.—Number of rabbits flushed per square mile during pre-hunting-season game-bird censuses on the Jasper County, Illinois, study area, 4 square miles, 1936-1941.

YEAR	NUMBER OF RABBITS PER SQUARE MILE
1936.....	4.5
1937.....	3.8
1938.....	11.2
1939.....	14.2
1940.....	8.5
1941.....	3.3

Table 9.—Number of rabbits flushed per square mile during pre-hunting-season censuses made by the United States Forest Service on sample areas of the Shawnee National Forest, in southern Illinois, 1935-1949.

YEAR	NUMBER OF RABBITS PER SQUARE MILE
1935.....	54.5
1936.....	50.8
1937.....	64.6
1938.....	89.8
1939.....	82.3
1940.....	87.8
1941.....	77.4
1942.....	—
1943.....	—
1944.....	—
1945.....	159.6
1946.....	69.4
1947.....	79.0
1948.....	54.3
1949*.....	54.3

*The United States Forest Service discontinued its censuses after 1948. Its wildlife report for the North Central states in 1949 stated that rabbit populations on the Shawnee National Forest were unchanged from 1948 to 1949.

ing 1938 and 1939, counts of rabbits killed on highways in southern Illinois were approximately six times as high as they had been in immediately preceding years. Table 8, showing numbers of rabbits flushed during game-bird censuses made by the Illinois Natural History Survey on a 4-square-mile study area in Jasper County in southeastern Illinois, indicates the trend of rabbit populations there during the period 1936-1941.

Table 9 shows estimates of the number of rabbits per square mile in the Shawnee National Forest in extreme southern Illinois during the period 1935-1949; the estimates are based on counts made by the United States Forest Service on sample areas of the different forest types. No censusing was done during 1942-1944. The Forest Service data indicate that the trend of rabbit populations in southern Illinois was in many respects similar to the trend in central Illinois, fig. 26, but some differences are apparent. For example, rabbit populations were high in both central and southern Illinois about 1939 and 1945, but, in the central counties, the population peak of the mid-1940's was considerably smaller than that of 1939, fig. 26. Also, rabbit numbers in central Illinois increased in 1948 and 1949, while in the Shawnee National Forest they apparently remained low.

Population records for the dark soil prairie region of east central Illinois cover a longer period of years than those for any other section of the state. Fig. 26 indicates the population trend during the years 1925-1949. The curve is based on highway "kill" records in central and east central Illinois for several years, morning roadside counts of live rabbits in and near Champaign County, 1942-1949, and bag records and field notes since 1925 of Joe L. Mote of Watseka, Illinois.

Mr. Mote is a veteran hunter and a competent observer of wildlife. His rabbit-kill data are particularly valuable because they cover a longer period than do any other known Illinois records. For years when he was unable to hunt, his notes give information on the abundance of rabbits. Although his records are from a single locality in east central Illinois, the indicated fluctuations of rabbit populations agree quite closely with those shown

by the records we have from other parts of central Illinois.

Rabbit populations are usually not exceptionally high in the dark soil prairie of central Illinois, and fluctuations are less pronounced there than in the southern counties. Nevertheless, it was observed during 15 recent years that general trends of rabbit populations in the central counties approximated those in the gray soil prairie of south central Illinois, where the cottontail rabbit populations were relatively high and where human tularemia was most prevalent.

As fig. 26 indicates, in recent years rabbit populations in central Illinois have shown major increases at intervals of about 10 years, with minor fluctuations between. It is of interest that in recent years population peaks of the prairie meadow mouse, *Microtus ochrogaster* (Wagner), in central Illinois have occurred there at approximately the same times as those of cottontail rabbits. Mohr (1947) mentions meadow-mouse highs in the winters of 1939-40, 1942-43, and 1945-46. According to an annual report by G. C. Oderkirk of the United States Fish and Wildlife Service, prairie meadow mice were exceedingly abundant in western and northern Illinois in the winter of 1946-47. In the autumn of 1949, members of the Natural History Survey staff found a recurrence of high meadow-mouse populations in the dark soil prairie of central and north central Illinois. Grange (1949) states, "Everything points to the fact, then, that Illinois Cottontails are geared to the Mouse cycle, and the cycle of Mouse-Rabbit predators." He does not discuss in detail the interrelationships of cottontail and mouse populations.

Field records indicate that, in Illinois, fluctuations of rabbit populations tend to be regional rather than state-wide. Differences in population trends frequently have been observed to be latitudinal. It may be noted by comparing figs. 25 and 26 that major population peaks in Wisconsin have not occurred during the same years as in central Illinois. Differences in the trends of cottontail populations probably account in large part for the previously mentioned differences in the trends of the tularemia rates in the Northern and Central regions of the United States.

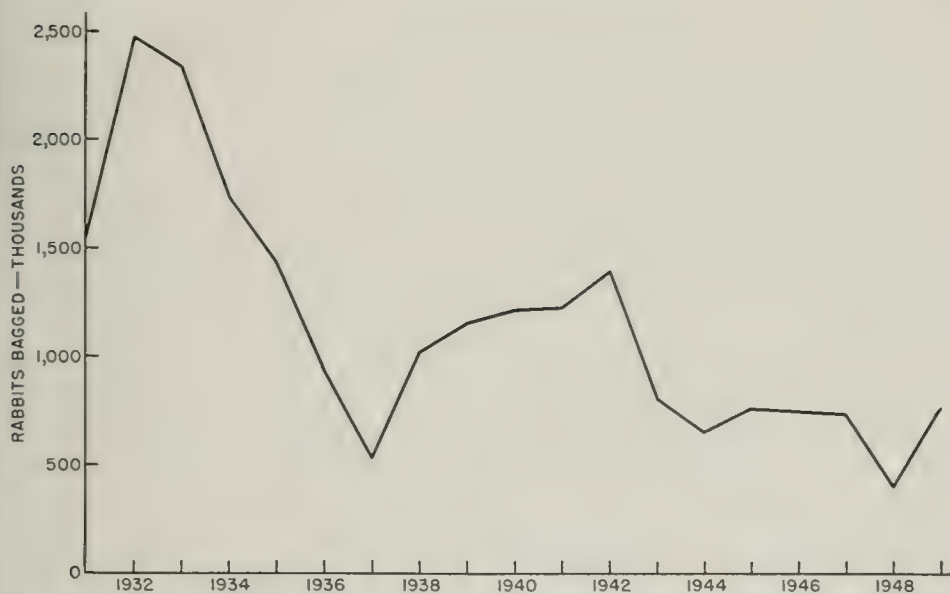


Fig. 25.—The calculated kill of cottontail rabbits per year in Wisconsin, 1931–1949. The basic data for this graph are from the Wisconsin Conservation Department.

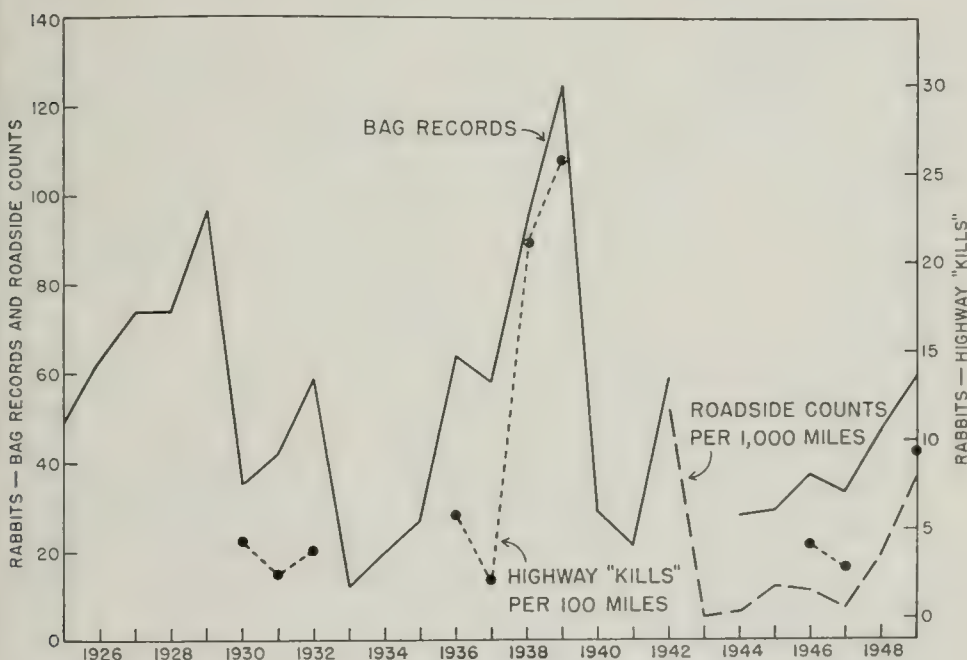


Fig. 26.—Cottontail rabbit population trends in central Illinois, 1925–1949, as indicated by bag records, highway "kill" counts, and roadside counts. Highway "kill" records for the years 1930–1932 are from Flint (1934) and for 1937 from Starrett (1938). The high rabbit populations of 1938 and 1939 were accompanied by a severe outbreak of human tularemia, fig. 24. Comparison of fig. 25 with fig. 26 indicates that major population peaks of rabbits did not occur in the same years in Wisconsin and central Illinois.

During periods of abnormally high rabbit populations, warm weather preceding the opening of the hunting season greatly increased the tularemia hazard in Illinois. In years when rabbit populations were unusually low, the tularemia rate remained low even during warm autumns, for example 1941, 1947, and 1948, fig. 24. When rabbit populations were average, the tularemia rate followed quite closely the curve of the mean date of the first 10 freezing autumn nights. Moderately high rabbit populations, such as occurred in the middle and late 1940's and probably in the early 1930's, brought increases in the number of human tularemia cases, but with these increases the disease did not reach epidemic proportions even during warm autumns.

Although there is evidence of more or less regular fluctuations in numbers of Illinois cottontails, our data do not indicate that many of these fluctuations are violent. The great population increase in 1938 and 1939 and the accompanying severe outbreak of human tularemia must be regarded as exceptional. Nevertheless, hunters should bear in mind that a sustained increase resulting in exceptionally high rabbit populations in their hunting areas may in turn favor a severe outbreak of tularemia among the rabbits.

At times, tularemia may be a factor that contributes to the decline of rabbit numbers following population peaks. Local tularemia outbreaks that were the apparent cause of reduction of cottontail populations from high to low levels have been reported by Waller (1940) and Hendrickson (1943) in Iowa, Hicks (1942) in Ohio, and others. It seems safe to assume, however, that tularemia is but one of numerous factors that contribute to population control among cottontails.

Tularemia and the Rabbit Hunter

Green (1942) has pointed out that tularemia is in large part a hunter's problem. This observation seems applicable to Illinois especially. At present, between 400,000 and 500,000 licensed sportsmen hunt annually in Illinois. In addition, many thousands of boys and men hunt on their home farms without being required to purchase hunting licenses. The great

majority of these people confine their hunting entirely to upland game. Although many of the Illinois hunters now refuse to bag cottontails for fear of contracting tularemia, most of them depend largely on rabbit hunting for their sport.

The importance of the cottontail rabbit as a game species in Illinois will be evident when it is considered that rabbits can be found on virtually every square mile of farm land in the state and in most cities and towns, and that they are usually present in huntable numbers through the open season, even in intensively cultivated districts. All other resident game species tend to be local in distribution. Because cottontails can be found close to home by most Illinois hunters, which makes hunting them a relatively inexpensive recreation, and because they have desirable sporting and table qualities, these rabbits in recent years have averaged more than one-half of the number of game animals taken annually by the hunters of the state.

Cottontail rabbits have usually increased in numbers readily under wildlife habitat improvement programs that have been conducted in Illinois. This tendency was illustrated on the Urbana Township Wildlife Area by the marked rise of rabbit populations, noted by the senior author, that accompanied the growth of hedges and blocks of shrubs and trees during the years following planting on the area about 10 years ago. In favorable habitats, rabbits usually can be hunted heavily year after year without permanent reduction of their population levels (Pirnie 1949). In fact, heavy hunting may be a desirable game management measure to reduce temporarily the population levels of rabbits and thereby lessen the danger of epizootics.

It seems highly desirable for hunters in Illinois and other states where rabbits are important as game to have reliable information on how best to avoid contracting tularemia while hunting. The medical profession has recently made marked progress in successfully combating the disease in man. Wildlife research workers and game administrators in many states undoubtedly can contribute materially to the solution of the tularemia problem by determining hunting practices and hunting seasons likely to afford the greatest protection to hunters.

Green (1942) observed that tularemia in rabbits and hares in Minnesota was chiefly a spring and fall disease. He found infection to be relatively uncommon in these animals during the summer months and very rare during the winter. On the basis of the observed decline of tularemia in winter, he had previously (1935, 1939) urged delay of rabbit hunting until after the onset of cold weather.

In describing tularemia in rabbits, Green (1942) stated, "Tularemia is a bacterial disease; that is, it is caused by a microbe which can be seen under an ordinary microscope. The germ can be grown in the laboratory and is easily recognized by a trained bacteriologist. When this germ infects an animal, particularly a rabbit, it grows in the blood stream and in all the internal organs of the animal and produces the disease which we call tularemia.

"When an infected rabbit is encountered in the woods, its reactions are usually slow and the animal appears somewhat tame. Regardless of tularemia, it is always best to take only rabbits or other wild animals

that show vigor and can be taken only with difficulty.

"The typical infection as found in a rabbit can be recognized by a peppering of tiny white spots on the liver and spleen. The white spots are abscesses caused by growth of the germ in those organs. The infection is of relatively short duration in rabbits and hares, usually lasting about seven days. Cottontail rabbits are very susceptible and always die; snowshoe hares are comparatively resistant and usually recover.

"On cleaning a rabbit, if the reddish-brown liver or spleen is seen to be peppered with fine white spots, the carcass should be burned, one's hands should be repeatedly washed with soap and water and finally, if possible, with a disinfectant. Any cuts on the hands should be treated with iodine."

Inasmuch as other conditions than tularemia may cause spotting of the liver or other internal organs, figs. 27 and 28, this symptom is not conclusive evidence of the



Fig. 27.—Lesions of tularemia on liver and spleen of a domestic rabbit, following experimental infection. The small white spots become visible on the liver and spleen about the third day of illness. Photo by Nick Kramis, photographer, Rocky Mountain Laboratory, United States Public Health Service.

disease in rabbits. Fig. 27 illustrates the characteristic appearance of the liver and spleen of a rabbit infected with tularemia. Tapeworm cysts are found rather frequently in the muscles or attached to internal organs of Illinois cottontail rabbits. These cysts are not related to tularemia and are harmless unless eaten raw, but it is better to discard an affected rabbit rather than to try to cut out the cysts.

It should be borne in mind that rabbits and other game may not exhibit visible symptoms of tularemia in early stages of the disease. Francis (1937) stated of infected rabbits that "innumerable small round spots [on the liver] become plainly visible on the third or fourth day of illness, but these spots are too small to be seen on the first and second days of illness. Therefore, if a rabbit is shot on the first or second day of illness the liver, though diseased, will appear healthy." Because it is possible for infection to be present in apparently healthy animals, thorough cooking of all game is always a wise precaution. Tularemia contracted by humans as a result of eating infected game that is insufficiently

cooked appears to be especially severe and is associated with a high death rate: Cooking of rabbits and other game until the bone marrow and the meat surrounding the bones are well done eliminates any danger of tularemia infection.

A number of organizations have advised hunters to wear rubber gloves when handling cottontails. Yeatter & Thompson (1943) have pointed out that this precaution, although probably offering a degree of protection, is not entirely practical and may give a false sense of security to hunters during tularemia epidemics. The hunter usually is bare handed when handling the gun, and during a day of hunting receives scratches from briars or barbed wire, or becomes chafed on the hands or wrists. In addition, as has been mentioned, considerable evidence indicates that infection can take place through the unbroken skin.

Although some hunters in recent years have put on cotton or leather gloves before picking up rabbits, they are probably in the minority. Every shot rabbit is smeared with blood, and, whether the animal is



Fig. 28.—Lesions of tularemia on lungs of a domestic rabbit, following experimental infection. Photo by Nick Kramis, photographer, Rocky Mountain Laboratory, United States Public Health Service.

carried in the hand or placed in a hunting coat, it may come in contact with the skin. Rubber gloves are not commonly used by hunters in the field, and, even though an attempt is made to use them while cleaning rabbits, there are several points of danger. The gloves may not be of sufficiently good quality, but, more important, the average hunter probably does not possess the training and skill required to use the gloves without puncturing them or to remove and sterilize them without contaminating the hands or face. Many laboratory technicians and medical workers have contracted tularemia even when all available facilities and known protective measures have been employed. Therefore, it is unlikely that rubber gloves alone offer the untrained layman much protection.

Although it would obviously be unwise to minimize tularemia as a hunting hazard, it should be pointed out that publicity given the disease by newspapers and radio has tended to instill in the public an exaggerated fear of becoming infected by handling wild rabbits during nonepidemic years or during late fall or winter months. The writers (Yeatter & Thompson 1943) have stated in this regard, "Tularemia is a serious disease and it is not our intention to underrate it, but it has been mostly a mental hazard since the peak years. The danger from car accidents and gun accidents, which is considerably greater, does not keep people from hunting. For example, in 1942, Illinois had 67 cases and one death from tularemia. In the same year Wisconsin, with almost the same number of licensed hunters had 109 gun accidents and 36 deaths. Comparable figures are not available for Illinois, but they are probably about the same as those for Wisconsin because 80 of the accidents and 24 of the deaths came during the small game season."

Hicks (1942), in recommending that the rabbit-hunting season in Ohio be delayed until December, pointed out that the delay in opening of the season would minimize the frequency of human tularemia and eliminate much of the psychological hazard which then detracted greatly from the pleasures of hunting in Ohio.

Hunters are not likely to follow elaborate precautions for handling rabbits skillfully enough to protect themselves from

infection with tularemia. The writers believe that Illinois hunters can most effectively reduce the tularemia hazard to a minimum by delaying rabbit hunting until after the onset of sharp, freezing weather. This delay is urged especially for hunters in the Central and Southern zones of the state, where rabbit ticks presumably are active later in the fall than in the Northern Zone. It should be remembered that periods of exceptionally high rabbit populations, such as occurred in Illinois in 1938 and 1939, increase the danger of infection and call for special measures on the part of hunters.

Within the past decade, methods of treating tularemia in humans have been improved greatly, principally through the use of antibiotics. The United States Fish and Wildlife Service Wildlife Leaflet 271 (Anonymous 1948) stated in regard to the use of streptomycin in treating tularemia, "Many remarkable recoveries with few failures . . . have been recorded following the use of this agent." Recently aureomycin and chloromycin have largely supplanted streptomycin in the treatment of tularemia. Probably the low death rate in Illinois in recent years, table 4, reflects the increasing use of antibiotics in treatment of the disease.

Recommendations

Detailed analysis of weather and tularemia records indicates that delaying the opening of the rabbit season until December is the most practical method for reducing tularemia in Illinois. Recommendation is therefore made that the opening date be changed to December 1 or, preferably, December 8, at least in the Central and Southern zones of the state. The opening date in the Northern Zone might, without serious hazard in most years, continue to be November 11. The gains to be expected from standpoints of public health and enjoyment of hunting seem to far outweigh any disadvantages that might arise from this proposed change in the game code. To compensate for the delay of the opening date, the rabbit season could be extended to January 30.

Because of its adaptability to farm habitats throughout Illinois, the cottontail rabbit is undoubtedly our most impor-



Fig. 29.—Illinois Natural History Survey entomologist examining wild cottontail rabbit for external parasites.

tant game animal. There are, however, a number of questions that need to be answered before the best use of this game animal can be made. Studies of population fluctuations should be continued, and records of long-time censuses on areas that are representative of the different sections of the state should be analyzed to give better methods for predicting population trends and possible disease outbreaks.

Studies should be made to supplement the investigations begun by Ecke (1948) for the Natural History Survey—studies involving the degree of infestation of rabbits by ticks and other tularemia vectors, fig. 29, the per cent of diseased animals, numbers of embryos per female, numbers of broods of young per female, weights,

food, and other phases of the life cycle. The relation of tularemia and its vectors to rabbits, and to other wild and domestic animals, should be further examined.

It seems evident from tularemia studies already completed that much progress in controlling the disease can be made by enacting legislation for confining the hunting season to the colder months of the year, by educating hunters to take adequate safeguards, and by warning the public of any significant increases in the tularemia hazard. In event that exceptional conditions arise, such as those in 1938 and 1939, it is suggested that the Illinois Department of Public Health, the Illinois Department of Conservation, and the Illinois Natural History Survey, working

jointly, bring such an emergency to the attention of the governor of the state so that he may by proclamation defer the opening of the rabbit-hunting season until after the principal danger has passed.

Summary

1. An analysis of the human tularemia records of the United States Department of Public Health indicates that, on the basis of tularemia rates and seasonal incidence of the disease, the United States falls into four general regions, namely, Northern, Central, Southern, and Western.

2. In a 24-year period beginning in 1926, Illinois had about twice as many reported human tularemia cases as any other state. The great majority of these reported cases was among residents of the southern half of the state.

3. The high incidence of tularemia among hunters, their families, and others in southern Illinois appears to be related to the greater abundance of rabbits in that region.

4. The human tularemia rate in any year in Illinois seems to be determined both by temperatures about the time of the opening of the rabbit season and by the abundance of rabbits. Very high rabbit populations increase the tularemia hazard.

5. When rabbit populations were average, the human tularemia rates followed the curve of the mean or average date of the first 10 freezing autumn nights. When rabbit populations were low, the tularemia rates remained low, even during warm autumns. The most serious outbreak of human tularemia known in the past half century was in 1938 and 1939 when rabbit populations were exceedingly high and the autumns warm until well past the opening date of the season.

6. Delay in the opening of the rabbit-hunting season until December 1, particularly in the Central and Southern zones of Illinois, is recommended as the most practical management method for reducing the amount of human tularemia. The Northern Zone may, without serious hazard in most years, continue to open on November 11.

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